Preliminary Report

DECISION ANALYSIS OF FIRE PROTECTION STRATEGY FOR THE SANTA MONICA MOUNTAINS: AN INITIAL ASSESSMENT

Prepared for:

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE
PACIFIC SOUTHWEST FOREST AND RANGE EXPERIMENT STATION
BERKELEY, CALIFORNIA

STANFORD RESEARCH INSTITUTE
Menlo Park, California 94025 · U.S.A.

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By: RONALD A. HOWARD
D. WARNER NORTH, *Project Leader*
FRED L. OFFENSEND
CHARLES N. SMART

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PREFACE TO THE SECOND PRINTING

The response to this report and the demand for additional copies have led us to reprint it in quantity for public release prior to the planned final version as a U.S. Forest Service research paper. In this second printing we have taken the opportunity to correct some minor errors and omissions. The text and the analysis remain essentially the same as in the original version. We have added as Appendix E our supplementary report on the Rolling Hills fire of June 22, 1973.

As stated in our original preface, we solicit from the reader comments and criticism on our approach, assumptions, and the numerical values used. These comments will be used in producing a final report that will describe our analysis of fire protection policy in the Santa Monica Mountains and in a high value watershed area of the Los Padres National Forest.

PREFACE

This report presents an initial assessment of a complex and difficult problem, fire protection for the Santa Monica Mountains in the City and County of Los Angeles. It has been our goal to delineate a systematic and comprehensive method for economic analysis of fire protection strategies. The demonstrated ability to evaluate quantitatively proposed fire protection alternatives constitutes a significant success in attaining this goal.

The purpose of this preliminary report is to present our analysis for circulation among those most knowledgeable about the Santa Monica fire protection problem. We solicit frank criticism from the reader on our approach, on possible omissions of important issues from our analysis, on any factual inaccuracies, and on the particular numerical values that we have used.

After appropriate revisions have been accomplished, the authors intend to publish this analysis together with our earlier analysis of fire protection strategies in a high value watershed area of the Los Padres National Forest.[1*] The combined final report will cover the research work accomplished under U.S. Forest Service Research Grants PSW No. 2 (October 1971) and PSW No. 6 (November 1972).

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[*] References are listed at the end of the text.

ACKNOWLEDGMENTS

In performing an analysis such as this, the decision analyst acts to structure the problem and to facilitate communication among concerned parties. He does not provide the information used in the analysis; this information must be supplied by the most informed individuals available. We have been fortunate in having the cooperation of a great many individuals from a variety of organizations who have given us their wholehearted cooperation. We are grateful for their assistance, and we take responsibility for any distortions we might have introduced. We would like to acknowledge particularly the contribution of the Los Angeles City Fire Department, the Los Angeles County Fire Department, and the Insurance Services Office.

SUMMARY

A. The Problem

Weather and vegetation in the Santa Monica Mountains make this area susceptible to intense wildfires. These wildland conflagrations threaten the destruction of millions of dollars worth of property in an area populated by approximately one hundred thousand people. This threat is a serious concern to the fire protection agencies, local government, the insurance industry, and area residents and property owners.

The aim of this research project is to carry out a comprehensive economic analysis of alternative strategies for protecting the Santa Monica Mountains from wildfire. The basic approach is to assess the costs and losses from fire that accrue to all concerned parties under alternative protection strategies. While this approach to planning fire protection has been advocated by planners and economists for many decades, assessment of total costs and losses has seldom, if ever, been the basis for determining wildland fire protection policy.* This research project provides a specific example of how the cost plus loss approach may be used to guide those responsible for setting fire protection policy.

B. The Alternatives

Three major approaches in a fire protection policy are:

- To reduce the number of wildland conflagrations.
- Given the number of wildland conflagrations, to reduce their extent.
- Given the extent of wildland conflagrations, to reduce the damage.

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*Arnold's Ph.D. dissertation includes a history of the cost plus loss concept;[2] and Davis' well-known text includes a chapter on it.[3] Some recent studies for the U.S. Forest Service of fuel break systems have made use of this concept.[1,4,5]

While all three approaches must be included in any fire protection policy, we shall examine as alternatives to the present situation policies in which one of these approaches is augmented considerably.

C. The Analysis

Conflagrations occur when an ignition is followed by a failure to control the fire at a small size. Conflagration incidence can therefore be reduced by activities that reduce ignitions and by increasing the promptness and effectiveness of initial attack. Fewer ignitions would lead to fewer large, uncontrolled fires. Our analysis indicates that a 10 percent reduction in number of wildfires might reduce the expected annual cost plus loss for the Santa Monica Mountains by as much as a million dollars. This is equivalent to the annual cost of adding fifty firemen to the area. While reduction in conflagration incidence appears to offer substantial savings, fire protection agencies have already pursued this policy, approaching a point of diminishing returns in the opinion of many experts.

Although most ignitions are promptly extinguished, a few fires will invariably escape under extreme weather conditions no matter how great the suppression resources are. In the opinion of fire experts, these fires burn until they run out of fuel or until the wind abates sufficiently for suppression efforts to be effective. Evidence based on the fuel characteristics of brush and past fire patterns indicates that the difficulty of suppressing a fire increases with the time since the area was last burned.[6,7]

A second approach to fire protection is to reduce the extent or size of the conflagrations that do occur. It is generally acknowledged that suppression efforts are ineffective against the head of a large fire under severe weather conditions, but suppression efforts can often limit the flanks and contain the head of the fire when weather conditions permit. Fuel breaks help suppression efforts. Such wide strips of land on which fuel volume has been reduced offer a chance of containing fires even under severe conditions. Nevertheless, the effectiveness of fuel breaks is limited because in high winds flaming brands or spots may travel as much as a mile in front of a fire. Experts indicate that, under severe weather conditions, a fuel break of a thousand feet to a half-mile wide would stop the head of a fire about half of the time.[8,1] In our analysis, we assumed that an area-wide system of wide fuel breaks of the type discussed by Stallings[9] would result in a 50 percent reduction in the size of fires and in the resulting fire losses. But if acquisition of the land is required, the system is clearly uneconomical: the average annual cost plus

loss would increase from $11 million to over $26 million. If, on the other hand, the fuel break system could be constructed without paying for the use of the land, the fuel break system would more than offset its costs in reducing fire losses: the average annual cost plus loss of $11 million would be reduced to about $8 million. Hence, means of acquiring fuel break rights (perhaps through tax incentives) merit further investigation.

The most promising approach for improving fire protection policy appears to be the third: reduction of damages from fires of given extent. Unlike much of the wildland area in Southern California, watershed damage appears to be of relatively minor concern in the Santa Monica Mountains. Soils are comparatively stable, and most of the rivers drain directly into the sea instead of depositing silt and debris into a reservoir or residential area. The main category of fire damage in the Santa Monica Mountains is direct damage to structures. Past experience has shown that the effectiveness with which structures can be protected depends on two factors--the type of roof and the proximity of the structure to brush fuels. Our analysis indicates the most cost effective way of reducing the Santa Monica fire problem is to improve brush clearance and roof resistance to fire.

The importance of roof type and brush clearance is well documented for the 1961 Bel Air fire. Four hundred eighty-four houses were destroyed of the 2,204 houses in the threatened area; the overall destruction rate was 22 percent. Most of the houses destroyed had either poor brush clearance, flammable wood roofs, or both. Of the 105 houses with wood roofs and brush less than 10 feet from the house, 57 were destroyed, a destruction rate of 54.3 percent. Of the 151 houses with approved fire-resistant roofs and brush clearance of at least 100 feet, only one was destroyed, a destruction rate of 0.7 percent; the difference in destruction rate was a factor of approximately 80.[10] Table 1 gives the destruction rate for various categories of roof type and brush clearance in the Bel Air fire.

The Bel Air statistics, compiled by the Los Angeles City Fire Department, are virtually the only data available correlating destruction rate with such factors as roof type and brush clearance. If we assume that these destruction rates characterize future fires in the Santa Monica Mountains, the implication is strong: Fire resistant roofs and brush clearance of 100 feet for all structures would reduce the average annual loss by nearly a factor of ten, from 60 houses per year to 7 houses per year (Table 2). The required program of brush clearance and roof conversion would be costly to the homeowners. But the reduction in fire losses and insurance costs more than offsets the program costs.

Table 1

PROBABILITY THAT A HOUSE OF GIVEN ROOF TYPE AND BRUSH CLEARANCE WILL BE DESTROYED, GIVEN THAT IT IS EXPOSED TO WILDFIRE
Destruction Rate Observed in Bel Air Fire*

Brush Clearance (in feet)	Fire Resistant Roof Type Approved by Insurance Industry	Wood Roof Type Unapproved by Insurance Industry
0-30	0.243	0.495
30-60	0.054	0.286
60-100	0.016	0.144
100+	0.007	0.148

*From the Los Angeles City Fire Department Records of the 1961 Bel Air Fire.[10] The sample included 1,850 homes. Values have been interpolated to match insurance industry brush clearance categories.

Table 2

COMPARISON OF PROTECTION POLICIES INVOLVING BRUSH CLEARANCE AND ROOF CONVERSION

Protection Policy	Average Annual Number of Homes Destroyed	Annual Cost of Protection Program (Millions of dollars)	Average Annual Cost plus Loss to Society, Including Program Cost (Millions of dollars)
Present situation: existing roof types and brush clearance	60	$0	$11.0
Native brush removed 100 feet from all homes and existing roof types	45	0.6	9.6
Conversion of all wood roofs from unapproved to approved type and existing brush clearance	21	3.1	8.9
Both brush clearance to 100 feet and conversion to approved roofs	7	3.7	7.6

The implementation of these programs would result in a lower total cost plus loss to society.

One way to implement this program is to make brush clearance and a fire-resistant roof a legal requirement. Both Los Angeles City and Los Angeles County have ordinances requiring that native brush be cleared within 100 feet of a structure and requiring fire-resistant treatment for wood roofs on new homes. But what the ordinances call "fire resistant" is not the same as what insurance companies call "approved."* In addition, there is a high degree of noncompliance with the ordinances by property owners. Table 3 shows the percentage of homes having various amounts of brush clearance and roof types for the city and county areas of the Santa Monica Mountains. If we compute the destruction rate from this data and the Bel Air statistics (Table 1), we arrive at a rate of 4.1 percent for the county and 6.9 percent for the city. These destruction rates are considerably lower than the 22 percent that occurred in the Bel Air fire, but they are far above the projected figure of 0.7 percent based on universal implementation of fire-resistant roofs and brush clearance to 100 feet.

A possible alternative to strict dependence on a brush and roof ordinance is to provide homeowners with an economic incentive to carry out roof conversion and brush clearance around their homes. An incentive system in fact already exists: the brush surcharge added to the fire insurance premium for homeowners in the Santa Monica Mountain area. Although this surcharge varies with roof type and brush clearance, the differences in premium are not as great as the differences in destruction rate observed in the Bel Air fire. For example, where both have brush clearance to 100 feet, the homeowner with an approved roof pays 80 percent of the premium paid by the homeowner with an unapproved roof. However, his expected losses are only 5 percent of the losses expected for the homeowner with the unapproved roof.

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*Insurance underwriters recognize pressure-treated shake (or shingle) wood roofs as "approved" fire-resistant roofs and give a premium reduction for this roof type. Ordinary wood shakes and those treated by the dip method are considered to be "unapproved" by insurance industry standards. The City and County ordinances permit either dip- or pressure-treated wood shakes. Little information is available on the effectiveness of dip-treated shakes in a wildfire situation; pressure-treated shakes have passed certain Underwriters Laboratories tests. We have used costs for pressure-treated shakes and destruction rates from the Bel Air fire for approved roofs in evaluating the roof conversion alternative. Only a few pressure treated-wood roofs have been installed in the Santa Monica Mountains.

Table 3

EXISTING PATTERN OF ROOF TYPES AND BRUSH CLEARANCE
IN THE SANTA MONICA MOUNTAIN AREA*

Los Angeles City Area
(10,551 homes in sample)

Brush Clearance	Roof Type		
	Approved	Unapproved	Both
0-30 ft	3.1%	0.6%	3.7%
30-60 ft	6.5	1.9	8.4
60-100 ft	8.0	3.3	11.4
More than 100 ft	49.8	26.7	76.5
Total	67.5%	32.5%	100.0

Average destruction rate, computed from Table 1, for the sample above is 6.9 percent.

Los Angeles County Area
(4,542 homes in sample)

Brush Clearance	Roof Type		
	Approved	Unapproved	Both
0-30 ft	4.1%	0.1%	4.2%
30-60 ft	8.9	0.3	9.1
60-100 ft	11.4	0.8	12.2
More than 100 ft	62.4	12.0	74.4
Total	86.7%	13.3%	100.0

Average destruction rate, computed from Table 1, for the sample above is 4.1 percent.

*Source: raw data from Ref. 11.

A brush surcharge schedule that reflected the likelihood of destruction would serve several important purposes. It would serve as economic incentive to homeowners to clear away brush, install fire-resistant roofs, and take other measures to reduce the potential for destruction of their property in a conflagration. The schedule would eliminate present inequities: no group of policy holders would be subsidizing another group whose expected claims would be higher in proportion to its premium payments. Finally, the premium schedule would serve as a clear signal to the homeowner of the difference in risk he faces. In addition to the cost the homeowner pays for insurance, uninsured losses, destruction of heirlooms, and the psychological trauma of losing his house are all strong motivation for the homeowner to reduce his risk. A homeowner who could perceive that his untreated shingle roof house is twenty times more likely to burn in a brush fire than his neighbor's approved-roof house might easily decide to replace his roof with a fire-resistant type.

Our analysis has been based on the Bel Air fire statistics, but we do not wish to imply that the destruction rates observed in this fire should be adopted uncritically as the destruction rates appropriate for setting insurance premium rates and for determining fire protection policy. We believe that a careful assessment should be made of how destruction rates depend on roof type, brush clearance, and, perhaps, other factors. Appendix C of this report gives percentage distribution of houses by roof type and brush clearance for each of the 46 areas into which we have divided the Santa Monica Mountains. The Bel Air statistics can be used to compute a destruction rate for each of these local areas; these figures should be critically reviewed by experienced fire experts to determine whether they represent reasonable estimates of the expected loss if a fire were to burn through those areas.

The cost plus loss method developed in this report may be used by fire protection agencies and local government officials to plan fire protection at the local level of individual canyons, small towns, or subdivisions. Example calculations given in the report evaluate brush clearance and roof conversion in Mandeville Canyon and a local fuel break in the town of Monte Nido.

D. Recommendations

1. Public Education

Fire agencies should emphasize that occasional large fires are inevitable in the Santa Monica Mountains and urge that steps be taken to minimize the loss when these conflagrations occur.

Large fires will occur in the future in the Santa Monica Mountains, just as they occurred in 1956, 1961, and 1970. Brush clearance and fire-resistant roofs should substantially reduce structural losses; other means of fireproofing structures should be investigated. Homeowners, insurance executives, developers, local government officials, and mortgage bankers should all be made aware of the potential for protecting structures from future conflagrations.

2. Insurance Surcharge Rates

The brush surcharge rates should be set to reflect expected losses. If present rates do not meet this criterion, they should be revised.

The brush surcharge is a special insurance premium to reflect the threat posed by wildfires. Although the surcharge provides some motivation for clearing brush and installing a fire-resistant roof, the incentive appears low in comparison to the difference these measures make in the probability that a house will be destroyed.

3. Planning for Fire Protection

Fire protection agencies should use least cost plus loss economic planning methods as illustrated in this report; fire research and planning groups should continue to develop them.

The analysis presented in this report is comparatively simple, both in concept and in execution; it provides a framework wherein all concerned parties may work toward planning better fire protection for the Santa Monica Mountains. Additional data sources need to be developed, and aspects of the methodology could profit from further refinement. Our recommendations for such refinement will be found in the last section of this report.

The applicability of the least cost plus loss planning method goes beyond the wildland fire problem in the Santa Monica Mountains. We believe this planning method should be applied to other areas of urban and wildland fire protection policy.

I INTRODUCTION

A. Boundaries of the Study Area

Our study will concentrate on the Santa Monica Mountain area of Southern California. This area extends over approximately 220,000 acres. It is bounded by the Los Angeles Basin on the east, the Oxnard plain on the west, the San Fernando Valley on the north, and the Pacific Ocean on the South. Rising to an average height of about 2,000 feet, the mountains are characterized by rugged terrain containing steep slopes, narrow canyons, and continuous expanses of native chaparral brush.

We shall limit our study to the "Brush Hazard Area" of the Los Angeles County and City portions of the Santa Monica Mountains. This area, judged by the Insurance Services Office to be acutely susceptible to wildfire, is approximately defined by the Ventura Highway and Boulevard on the north; Griffith Park on the east; Sunset Boulevard and the Pacific Ocean on the south; and the county line on the west. (The study area, as shown in Figure 1, does not include some of the peripheral regions where there is little direct brush exposure.) This region encompasses 70 percent of the total mountain acreage and is distinguished by its relatively high concentration of residential housing developments. It contains about 30,000 homes with an average insurable value of approximately \$50,000* per home.

B. The Santa Monica Mountains and Wildfire

Historically, the Santa Monica Mountains have been prone to frequent brush fires. While most of the fires are contained through prompt initial attack, some invariably escape to become major conflagrations, burning thousands of acres and large numbers of homes. Unfortunately, very little can be done to control these fires once they become large. They burn until either the fuel runs out or until the wind dies down sufficiently

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*This value is a composite estimate obtained from real estate personnel and L.A. County tax assessors familiar with the Santa Monica Mountain area.

for suppression efforts to be effective. Some Santa Monica fires, such as the Wright fire of 1970, have burned all the way to the Pacific Ocean. Others, like the Bel Air fire of 1961, have not only burned over a large area but have also destroyed several hundred homes in the process. A comprehensive summary of the geographical factors influencing fire and the major fires in the Santa Monica area is presented by Weide.[12]

1. The Contributing Factors

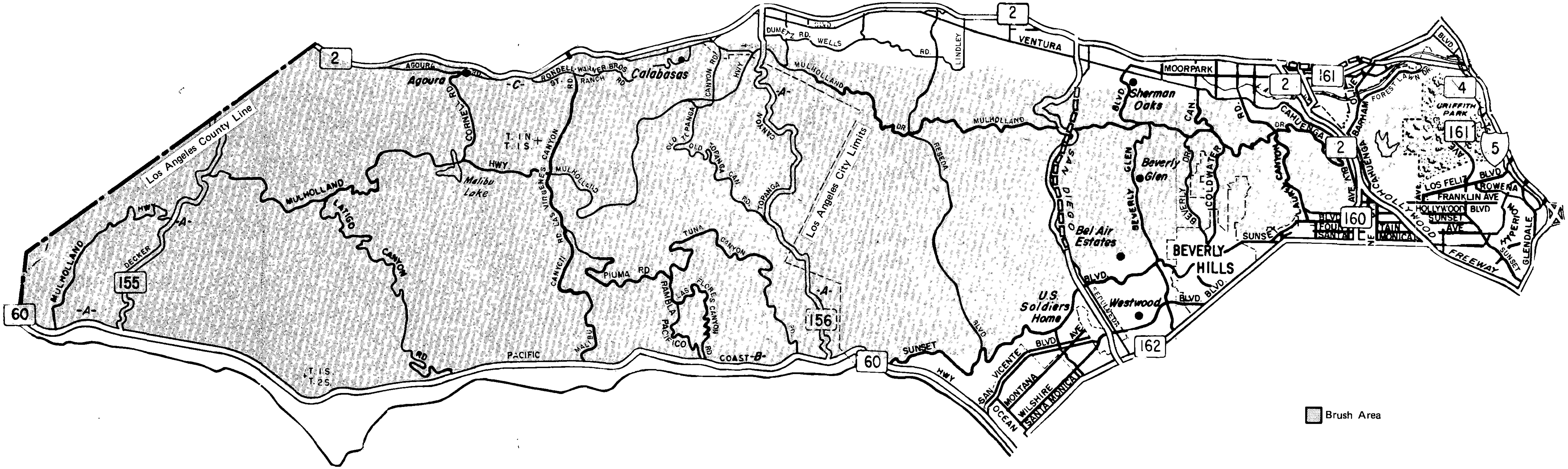
To appreciate fully the extent of the fire problem in the Santa Monica Mountains, however, one must understand the main contributing factors to wildfire in that area. These factors include the existing vegetation cover, prevailing weather conditions, topography, and the extent of local population concentrations.

The existing vegetation in the Santa Monica Mountains is chaparral. The chaparral exists in continuous sections stretching over much of the mountain area. Because it is extremely flammable, it constitutes a large, ready source of combustible fuel for a wildland fire.

The prevailing weather conditions existing in Southern California also contribute to the fire hazard. The area is characterized by dry, arid summers and periods of low humidity that tend to drain the moisture from the existing brush cover. During the most critical months of the fire season, from September to January, these conditions are intensified by the periodic onset of "Santa Ana winds" originating in the great basin to the northeast and traveling across the Santa Monica Mountains to the Pacific Ocean. These hot and dry winds desiccate the ground vegetation. Since the winds can gust to speeds of up to 100 miles per hour, they can propel the front of a brushfire at such an intense pace that control of the firehead becomes virtually impossible.

The topography also enters into the fire scenario for the Santa Monica Mountains. The steep canyons contour the land and promote atmospheric currents that reinforce any prevailing winds feeding a wildfire. Furthermore, since the mountain terrain is comparatively rugged, road construction has been restricted to relatively few accessible areas, limiting the effectiveness of ground fire-fighting crews.

The population is a potential source of fire in the area. The mountains provide a desirable residential area for large numbers of people. Close proximity to the rest of Los Angeles results in many contacts with the metropolitan population. This interface has accounted for most of the major fire starts in the area.



*Source of map: Insurance Services Office, Los Angeles, California.

FIGURE 1 THE STUDY AREA: THE BRUSH HAZARD AREA OF THE SANTA MONICA MOUNTAINS*

2. Possible Solutions

The region's extremely flammable brush cover, dry and windy weather, rough topography, and accessibility to metropolitan populations provide an ever-continuing basis for major wildland/urban conflagrations in the Santa Monica Mountains. Given this situation, the question that must obviously be addressed is: what can be done to protect the Santa Monica Mountains from wildfires? Several solutions have been proposed ranging from the creation of extensive fuel break systems to the encouragement of measures that protect the individual homeowner's property from fire.[9,18,20,23-25] The purpose of this decision analysis is to bring together expert information about all aspects of the fire protection problem, so that alternative programs of fire protection can be compared in a logical, comprehensive manner.*

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*The reader is encouraged to see our earlier report on the Los Padres National Forest as another illustration of this approach.[1]

II THE DECISION ANALYSIS APPROACH

A. The Methodology

To use decision analysis methodology, we must define the alternatives and the criteria by which they are to be evaluated. Each consequence of a fire protection alternative must be converted to economic terms, so that all factors can be compared on a common monetary scale. We want to determine the total cost plus loss to society of implementing each protection alternative.[3,4,13] The assessment of cost plus loss must include both the direct and indirect effects of fire, including damages to structures, watershed, aesthetics, wildlife, and disruption of normal business activities.

To make this assessment, we must determine the future cost and loss implications for each program considered. We will depend heavily on expert judgment and utilize historical data so far as available and appropriate. For this pilot analysis, we shall work only with average values. (In carrying out a more detailed analysis, one could develop probability distributions on total cost plus loss for the different protection alternatives. The approach of developing probability distributions on total cost plus loss is discussed in our earlier report.[1])

Since costs and benefits occur at different points in time, they must be discounted to the same point in time using an interest rate that reflects the time value of money. Most of the costs to be considered in our analysis are easily expressed in annual terms, and we shall use the annual cost method of discounting future cash flows, annualizing any capital expenses over the life span of the alternative.*

Our objective is to find the protection alternative that results in the least cost plus loss to society. This will be the optimum protection alternative. Note that the optimum alternative will not necessarily minimize total damage, because the cost of suppressing certain fires may exceed the expected reduction in damage.

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*In another report,[1] we use a different but essentially equivalent approach: All future cash flows were discounted to compute a total present value for each alternative.

B. Assessment of Fire Losses

The major category of fire loss in the Santa Monica Mountains is damage to improvements, mainly dwellings. For simplicity of presentation we shall approximate losses to improvements as a simple function of homes destroyed. Since most homes are covered by fire insurance, the insured and uninsured losses must be added to determine the overall structural loss. The assessment of cost plus loss must also include the insurance systems costs (the costs of providing insurance service over and above the actual claims).

We shall ignore fires of structural origin, considering only fires that originate in the wildland setting. (It is assumed that fires of structural origin have approximately the same frequency of occurrence in the Santa Monica Mountains as elsewhere in the state.) Our concern with fire insurance, therefore, will be directed only toward the special brush surcharge that reflects the threat of wildland conflagrations. The basic fire insurance premiums covering fires originating in or near the structure will be ignored. The structure of brush surcharges will be discussed in detail later.

Our inquiries indicate that fire-related flood damage in the Santa Monica Mountains is of secondary importance compared to the structural damage that occurs when fires burn into urban areas. The Los Angeles Flood Control District has found that Santa Monica vegetation is 95 percent recovered in six years, less than the 15-year figure often cited for brush in inland areas. Massive erosion and mud slides are rare, and most of the streams in the study area empty into the ocean, flushing most of storm-caused debris directly out to sea. The fact that very few flood control structures have been built in the Santa Monica Mountains compared to other parts of the Los Angeles basin is additional evidence that watershed damage is of secondary importance in that area.

A number of other factors must be considered in our inventory of cost and losses. We include possible loss of human life; damages to aesthetics, recreation, wildlife; and disruption of business services in the area that occurs as a result of fire. These losses must be expressed in economic terms if all categories of cost and loss are to be compared on a common scale. The cost of fighting a brush fire and the marginal suppression cost incurred in fighting a large fire are also included. The brush fire cost is the on-going cost of maintaining a brush fire-fighting organization. The marginal suppression cost should include any opportunity costs associated with resources whose use in fighting brush fire precludes use for other purposes.

Finally, we must include the costs of originating a new wildland fire protection policy. These costs may represent expenditures by the landowner and property owner for fuel modification or expenditures by the fire protection agencies for men and suppression equipment. Some protection strategies, such as closing an area, may create opportunity losses. For example, area closure denies opportunities for recreation to the public.

III BACKGROUND INFORMATION

A. The Parties Concerned

Although we seek the alternative that minimizes the expected annual cost plus loss to society as a whole, we shall also view the protection programs from the several perspectives of the different parties concerned with fire protection in the Santa Monica Mountains. These parties are state and local governments, fire protection agencies, private property owners, and insurance companies. The various protection strategies affect the different parties in different ways, and so the most attractive protection policy from the standpoint of society will not necessarily be the most attractive one for a particular party. It is important that we understand the different perspectives so that we can consider incentives to make an alternative that is preferable from the standpoint of society more attractive to the individual parties.

Most of the land in the Santa Monica Mountains is owned by private parties. No single group has exclusive responsibility for managing the Santa Monica Mountains as the U.S. Forest Service has in national forests. As a result, different parties must cooperate in any fire protection program for this area.

Figure 2 shows the interdependency of the four principal parties that are concerned with fire protection in the Santa Monica Mountains. The government influences each of the other three parties. Local government provides operating funds for the fire protection agencies,* establishes ordinances to eliminate certain fire hazards, levies taxes on property owners, and may grant fire protection subsidies to certain homeowners and landowners. State government, by regulating the insurance industry through a public commission, influences the applicable insurance structure.

The insurance companies establish their rates so as to cover expected losses and operating expenses stemming from damage in an area.

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*State funds are also provided to Los Angeles County to protect certain lands of the State of California.

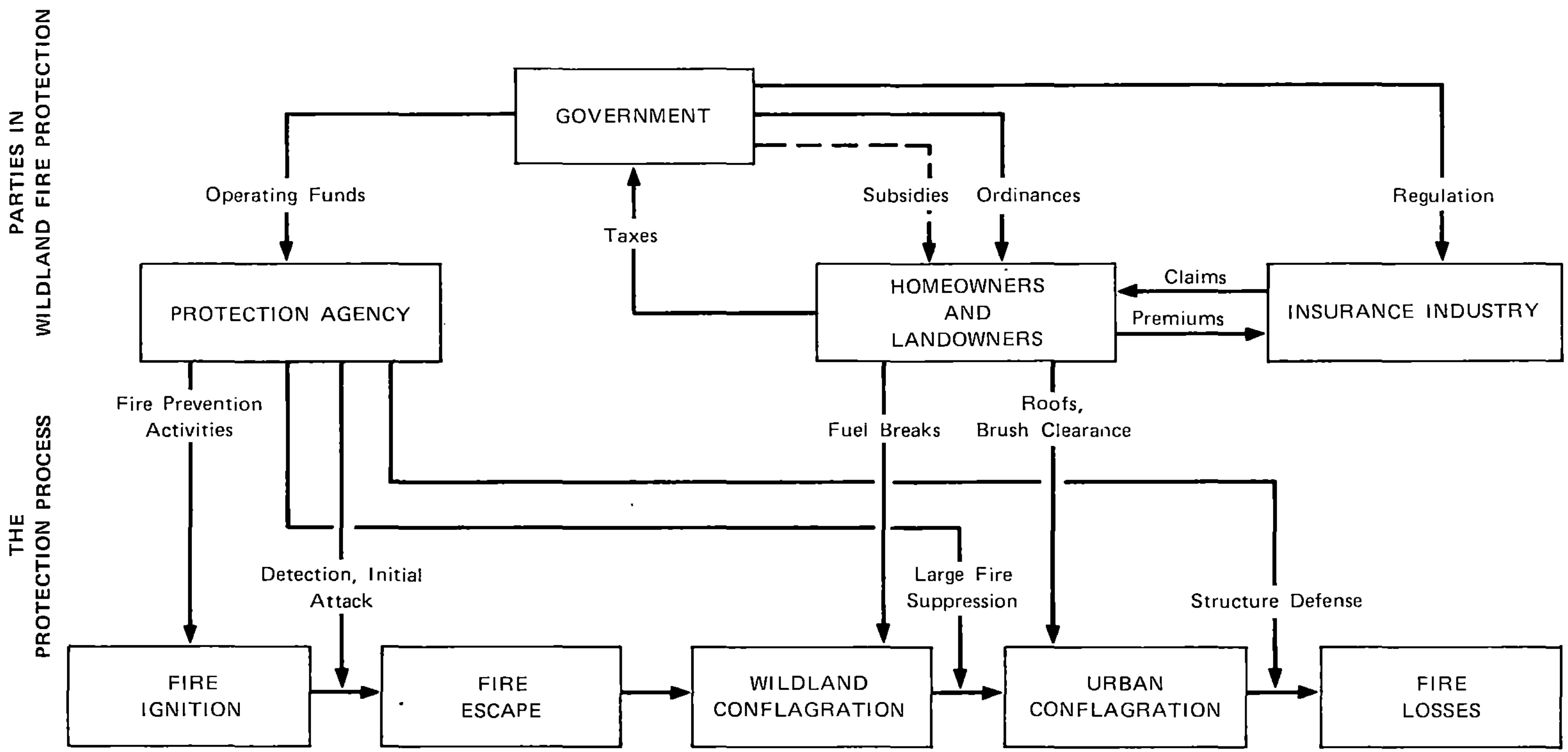

FIGURE 2 THE PARTIES AND THE PROCESS OF FIRE PROTECTION IN THE SANTA MONICA MOUNTAINS

The amount that the individual homeowner pays in insurance premiums and local taxes is dependent on the fire hazard present and the level of protection desired, both of which are partially under his control.

Many protection programs require the cooperation of local residents before the fire occurs. Fuel break systems, brush clearance, and roof conversions require the direct participation and the concurrence of individual property owners. The eventual success of fire suppression tactics and structural defense measures can be significantly affected by these actions on the part of private individuals prior to the wildfire.

The outcome of any fire protection policy can be described in terms of fire-related losses, but the overall criterion of minimizing the expected cost plus loss ignores the more basic question of <u>who</u> will bear the losses. We believe that it is important to examine the tradeoff between policies implemented by fire agencies and policies implemented through actions taken by property owners, who see the problem from a different perspective than the total cost plus loss to society.

The property owner incurs several costs and losses from wildfire. His costs include taxes that pay for fire protection; insurance premiums; and the costs of protective measures that he takes himself, such as brush clearance and roof conversion. His potential losses include direct damage to his property and the subjective loss that he feels as a result of a fire occurring in his neighborhood. A question that deserves extensive investigation is how to motivate property owners to adopt policies that minimize the total cost plus loss to society. Tax incentives, governmental subsidies, revision of insurance premiums, and local zoning ordinances are all steps that could be taken to effect such motivation.

B. Historical Data on Fires in the Santa Monica Mountains

During the period 1925 to 1952, the Santa Monica Mountain area experienced 23 major wildfires that burned an average of 4,200 acres per year. During the subsequent 18 year period there were 21 major fires that burned an average of almost 6,000 acres per year.* Most authorities attribute the increase in annual acres burned to the surge in population growth that began in the early 1950s.

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*According to Los Angeles County Fire Department Records.

1. Burn Rate

Records of structural loss due to wildfire before 1953 are not complete, but since there has been a marked increase in the rate of fires since that time, we will limit our statistical analysis to the period 1953 to present. Fire department records reveal that 831 homes were destroyed in brush fires of over 100 acres each during the period 1953 to 1970, an average of almost 46 homes per year. During the same period, the number of homes in the area averaged 23,000. Extrapolating this burn rate to the 30,000 homes that are currently in the area, we find that the present expected burn rate is 60 houses per year.

Historical data are not readily available on small brush fires of less than 100 acres in the Santa Monica Mountains. If the experience of the 1970 southern California wildfire season is appropriate, only a small number of homes are destroyed by small brush fires. Of the 722 homes destroyed in the 1970 fires, only 3.5 percent were destroyed in fires of less than 100 acres.[14] In our analysis we shall assume that small brush fires have a negligible effect on the average dwelling burn rate in the Santa Monica Mountains.

2. Cycle Time

A useful concept in understanding fire frequency is the cycle time, which we shall define as the average time between occurrences of fire in a specific location. If the average acreage burned in the 150,000-acre study area is 6,000 acres per year, 25 years elapse, on the average, between fires that burn a particular acre. Because fire-fighting forces in the Santa Monica Mountains have historically emphasized the defense of structures, the cycle time for houses in this area has tended to be somewhat greater than the cycle time for acreage. As described in Section V-C-2-a, we presently assess the cycle time for dwellings to be 30 years.

Cycle times ranging from 20 to 50 years may be considered appropriate in planning fire protection for the Santa Monica Mountain area. Philpot and Rothermel have noted that the flammability of chaparral increases markedly with age.[7] Historical data from the Southern California National Forests have indicated it is relatively rare for large fires to burn over the same area within 20 years.[6] On the other hand, the extreme flammability of mature chaparral fuels implies that cycle times greater than 50 years may be extremely difficult to achieve except by massive programs of fuel modification: A fire started in old brush under severe Santa Ana weather conditions may spread at such a rapid rate that a

successful initial attack is virtually impossible no matter how prompt it is or how great the fire fighting resources are.

3. The Bel Air Fire of 1961

Most of the damage in the Santa Monica Mountains has occurred in a relatively small number of severe fires. Post-mortem analysis of the losses in these fires has tended to be in qualitative rather than quantitative terms. It is widely believed that roof type and proximity to brush fields are important in determining whether suppression forces will be able to save a house from burning, but little quantitative examination of these issues has been carried out. A major exception was the 1961 Bel Air fire.

The Bel Air fire burned 6,090 acres in the city of Los Angeles during a two-day period in November of 1961.[10,15-18] Of the 2,204 homes exposed in the burned area, 484 were destroyed. The destruction rate was therefore 22 percent, or four times the 5 percent rate for the 1956 Malibu fire.[19] Destruction rates are not readily available on other large fires. They could be computed from burn perimeter maps, records of houses destroyed, and records of houses in the burned area at the time of the fire, but such calculation would entail considerable effort.

The Los Angeles City Fire Department compiled detailed records on the damage of the Bel Air fire by individual structures.[10] These records permit an examination of roof type and brush clearance on destruction rate, because one can determine the frequency with which homes in a given category were burned. The raw data is given in Table 4 in percentage and ratio form. The data covers the number of dwellings destroyed and the number of buildings exposed. (While it would have been better to count dwellings or buildings throughout, the discrepancies introduced seem to be slight.) The same data have been summarized graphically by Rexford Wilson.[17]

The table shows clearly that homes with wood shingle roofs unapproved by fire insurance standards fared much worse than homes with tile, composition, or flat modern roof types. The destruction rate for houses with wood shingle roofs was nearly three times the rate for houses with approved roofs. The importance of roof type becomes even more dramatic when the effects of brush clearance and roof type are considered simultaneously. For example, the rate of destruction for houses with unapproved roofs <u>and</u> brush clearance of less than 10 feet was greater than 50 percent; the comparable rate for houses with approved roofs and

Table 4

BEL AIR FIRE STATISTICS

Roof Type	Brush Clearance (feet) 1-10	11-25	26-50	51-100	100+	Total*
Wood (unapproved)						
dwellings destroyed/ buildings exposed	57/105	101/214	104/363	28/195	31/200	370/1288
destruction rate	54.3%	47.2%	28.7%	14.4%	14.8%	28.7%
Non-Wood (approved)						
dwellings destroyed/ buildings exposed	39/104	28/171	13/239	2/118	1/151	97/894
destruction rate	37.5%	16.8%	5.0%	1.7%	0.8%	10.8%

Overall Destruction Rate = 22%

*Note: Since some houses were not classified by brush clearance, totals across rows do not match the last column.

brush clearance greater than 100 feet was less than one percent. The difference is greater than a factor of 50.

In his report on the Bel Air fire,[18] Rexford Wilson made an even stronger conclusion about the importance of roof type and brush clearance. Wilson held that spotting by wood shingles was an important contributor to fire spread, and the existence of wood (unapproved) roofs increased the probability that other homes would be destroyed:

> Had there been no combustible roofs on the buildings in Bel Air, fire would have been forced to burn buildings by direct exposure. This fast advancing fire line, even with normal spot fires could be identified, followed and usually defended against. Had roofs been fire-retardant, each fire fighter would have been able to defend more homes and, thus, available forces could have stretched significantly further. Had the wood shingles not been present, there would not have been the three major jumps far ahead of fire fighters. As a result, in my judgment, had wood shingle and shake roofing not been present, there would have been between 350 and 430 homes saved. Thus, with all the other factors the same but with fire-retardant roofing, the building loss in this fire probably would have been reduced to between 50 and 130 homes.
>
> Had each of these 50 to 130 homes had the proper exposure protection from the surrounding brush and fire-retardant roofing, the loss in homes probably would have been further reduced to about 10 to 30 homes. Thus, homes can be designed to withstand serious threats from brush and forest fires through the proper protection from a shower of brands, and through proper exposure protection.
>
> The serious brush fire in Bel Air would have remained a serious threat, but with proper design an estimated 450 to 470 homes could have been spared destruction.[18]

C. The Brush Surcharge in Fire Insurance

Fire insurance in the Santa Monica Mountains is composed of two parts: a basic rate and a brush surcharge. The basic rate is determined according to the protection class where the house is located, the protection class depending on such variables as available water supply and fire department response time.[21] Eighty-three percent of the homes in the study area are in protection classes 2, 3, or 4; 2 percent are in

classes 9 and 10; and the remaining 15 percent are in intermediate classifications 5-8.*

The brush surcharge is intended to reflect the added fire hazard due to the surrounding brush. The surcharge is calculated for each individual house based on four factors--protection class, fire department response time, roof construction, and brush clearance. The surcharge increases with protection class and response time, but not uniformly. A 20 percent reduction is given for houses with fire retardant roofs.† To reflect the importance of brush clearance and its effect on direct fire exposure, the surcharge increases with decreasing distances of brush clearance. The maximum rate is charged for houses with less than 30 feet of clearance. The maximum surcharge rate increases sharply from $0.50 per $100 of insured valuation for protection classes 1-4 to $1.60 for protection classes 9 and 10. No reduction in premium is granted in protection classes 9 and 10 for brush clearance less than 100 feet.

Table 5 shows brush surcharges for a $50,000 home in various protection classes by brush clearance and roofing classification. The surcharge varies from $40 to $800, quite a range when compared with the basic fire insurance premium range of from $54 to $179. The maximum surcharge is charged for a house in protection class 10 having less than 30 feet of brush clearance and an unapproved roof. This homeowner would still be charged the same amount if he cleared his brush to 60 feet, whereas homeowners in lower protection classes get a 50 percent reduction in surcharge for clearing their brush to 60 feet.

Also calculated in Table 5 are the reductions in surcharge for having an approved roof installed. Note that these reductions are not as great as the differences in destruction rate observed in the Bel Air fire.

The rate structure of the brush surcharge should be examined with respect to the general criterion by which insurance rates are determined in California. Insurance rates are set so that the revenue received in insurance premiums covers both the expected claims from insured losses and the other costs incurred by the insurance company in conducting their

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*From Brush Surcharge Books available from Insurance Services Office, Los Angeles, California.

†Brush Surcharge Table available from Insurance Services Office, Los Angeles, California.

Table 5

PRESENT BRUSH SURCHARGE RATES FOR A $50,000 HOUSE*

Approved Roof

Protection class	1-4		5-6		7-8		9-10	
Response time	A	B	A	B	A	B	A	B
Brush clearance								
Under 30 feet	$200	$200	$240	$240	$320	$320	$640	$640
30 feet	140	180	180	240	270	320	640	640
60 feet	100	140	120	160	160	240	640	640
100 feet	40	80	60	120	120	160	480	560
200 feet	0	0	0	0	80	120	320	400

Unapproved Roof

Protection class	1-4		5-6		7-8		9-10	
Response time	A	B	A	B	A	B	A	B
Brush clearance								
Under 30 feet	$250	$250	$300	$300	$400	$400	$800	$800
30 feet	175	225	225	300	350	400	800	800
60 feet	125	175	150	200	200	300	800	800
100 feet	50	100	75	150	150	200	600	700
200 feet	0	0	0	0	100	150	400	500

Incentive for Approved Roof: Difference Between Approved and Unapproved

Protection class	1-4		5-6		7-8		9-10	
Response time	A	B	A	B	A	B	A	B
Brush clearance								
Under 30 feet	$ 50	$ 50	$ 60	$ 60	$ 80	$ 80	$160	$160
30 feet	35	45	45	60	80	80	160	160
60 feet	25	35	30	40	40	60	160	160
100 feet	10	20	15	30	30	40	120	140
200 feet	0	0	0	0	20	30	80	100

*Source: Table of Brush Surcharge Rates Provided by Insurance Services Office, Los Angeles, California.

business. In California, 55¢ out of every premium dollar is returned to the policy holder to cover actual losses. The other 45¢ is used to cover sales and other overhead costs to the insurance company and to provide a return on equity capital. We shall call this portion of the premium the insurance systems cost.

The regulatory criterion is applied to fire insurance premiums charged in the state as a whole; adjustments are based on totals over a five year period. If more than 55¢ per premium dollar is being paid out in claims, it is judged that the premium rates need adjustment upward; if less than 55¢ of the premium dollar is being paid out, a premium rate reduction may be indicated. Revision of rates for the brush surcharge on a regular schedule is not feasible. The losses are not regularly spaced in time, but occur only in severe fire seasons that may be many years apart. The present surcharge structure was established on the basis of expert judgment in 1961 and revised slightly in 1964. Insofar as we are aware, there has not been an overall determination as to whether the brush surcharge is equitable in terms of the general regulatory criterion. Insurance industry sources speculate that the insurance industry loses money on the brush surcharge, but that this arrangement represents an improvement over the situation prevailing before the brush surcharge premium went into effect because a reasonable market for fire insurance has been established.* (Prior to 1961, many insurance companies refused to write fire insurance policies in the high brush hazard areas except where forced to do so under assigned risk types of legislation.)

Ideally, if the present regulatory criterion is correct, it should apply down to the individual homeowner. We shall assume that the criterion is appropriate for the brush surcharge and make use of it in the analysis that follows. If p is the probability that an individual's house burns down due to wildfire in a given year, then his insurance premium should be:

$$p \times (\text{value of house}) \times \left(1 + \frac{45}{55}\right) \quad .$$

The premium is composed of two terms, the average amount the insurance company can expect to pay in claims (p × value of house) and the insurance systems cost, a term corresponding to the overhead costs and return on equity for the insurance company. The insurance company plays the averages

*In Appendix D it is estimated that the surcharge revenues are sufficient to cover only about one half the costs of insuring the Santa Monica Mountains from wildfire.

by insuring many homeowners. The individual pays nearly double his expected loss to avoid the financial risk that his house will be destroyed by fire.

The issue is, then, how to determine the probability of loss in setting insurance rates. At one extreme, one probability could be assigned for the population as a whole, and at the other extreme, a separate probability could be assigned for each policy holder as a basis for setting his premium rate. A reasonable compromise procedure is to group policy holders into categories according to brush clearance, roof type, protection class, and possibly other factors, and to assign a probability to all of the individuals within each category.

The regulatory criterion should then apply separately to each category: the average of the claims in the category should be 55 percent of the revenue collected from the category. If the criterion is met for the population as a whole, but not met for the categories that make up the population, then one group of policyholders will be subsidizing another group by paying more in premiums in proportion to the amount they are receiving back in claims.

If probabilities are assigned on the basis of the frequency of destruction observed in the 1961 Bel Air fire, it is apparent that such an implicit subsidy is now being included in the brush surcharge premium rate structure. Despite the 20 percent premium reduction, homeowners with approved roofs will be paying proportionally more than they receive in claims when compared with the homeowners with unapproved wood shingle roofs. In our analysis we shall investigate revised premium rates that reflect the Bel Air fire statistics, and examine the effect of the revised rates in motivating the individual homeowner to install a fire-resistant roof and to clear brush from around his house.

Before leaving the subject of fire insurance premiums, we shall draw one other implication for our analysis. The fire insurance premium is composed of two parts: a part to cover claims and a part to cover overhead expenses. The average total cost of wildfire to property owners should be the amount they pay in premiums plus their average uninsured losses, or to put it another way, it is the average amount paid in claims plus an insurance systems cost plus the average amount of uninsured losses. The regulatory criterion is that the insurance systems cost should consume no more than 45¢ of the premium dollar; the rest is paid back to policy holders as claims. The implication for our analysis is: if improved fire protection can lead to a reduction in claims, premiums

and the insurance service cost can be reduced proportionally. Thus, if an average of $1,000,000 a year of insured fire losses can be averted, the savings to fire insurance policy holders will be

$$\left(1 + \frac{45}{55}\right) \times \$1,000,000$$

or $1.81 million. One million of the savings is in the reduced claims; the remainder of 0.81 million is reduction in the insurance systems cost due to the decreased volume of business. In our analysis we shall include these savings from reduced insurance systems cost. In practice, the premium structure might not be revised until substantial evidence was accumulated that the fire threat had been reduced, and during this time the cost savings would accrue as profit to the insurance companies.

IV ANALYSIS OF THE PRESENT SYSTEM OF FIRE PROTECTION

A. The Costs and Losses for the Present System

Before examining the various protection alternatives, we shall determine the annual cost plus loss for the present system of fire protection. This will provide a basis for comparing other alternatives developed in the next section.

1. Loss of Structures from Wildfire

As already outlined, we presently assess the average annual burn rate to be 60 houses per year. This does not necessarily mean that 60 houses will burn every year, rather that the average will be 60 houses over a long period of time.

Major fires tend to occur in groups during infrequent severe fire seasons. Most of the damage caused by fires in the Santa Monica Mountains in the last twenty years occurred during three years: 1956, 1961, and 1970. During the remaining years there were few major fires and relatively little damage was caused by them. The values of 60 homes destroyed and 6,000 acres burned per year are averages over a burn pattern composed of a few severe years interspersed with many years in which no major fire occurs. For example, these averages would result from a pattern in which fires occur only every fifth year, but in that year they destroy 300 homes and burn 30,000 acres.

Housing values in the area range from around $20,000 to more than $200,000 per home. From discussions with real estate agents and tax assessors, we count the average house to be worth about $65,000. About $25-$30,000 of this amount is land value, leaving the average structure value at $35,000-$40,000. Since the value of buildable land is little affected by wildfire, we will only consider the value of the structure and contents when figuring insured losses. After discussions with insurance and fire officials, we set the average market value of contents at 20-25 percent of the total property value, or about $10-$15,000 per home. Thus, as a first approximation, the average house and contents in the study area have an insurable value of $50,000.

But most homeowners face a larger potential loss than what is normally covered by insurance. Some of these losses are tangible (such as goods not included under the policy) while others are more subjective (such as the psychological trauma of fire). It is admittedly difficult to assess these intangible losses, yet they must be considered in any comprehensive evaluation of fire protection policy. As an approximation, we will arbitrarily assume that the average homeowner faces a potential uninsured loss at a value of $10,000, that is, he would forego a potential payment of $10,000 to avoid the uninsured consequences of a fire. This issue deserves more refinement; in a later section of our report we will examine how critical this assumption is to policy selection.

The expected burn rate of 60 houses per year results in an average insured loss of $3 million per year. Associated with this loss are the insurance systems costs. At 45/55 of the insurable claims, this cost is $2.45 million per year. And at $10,000 per destroyed house, the uninsured losses average $600,000 per year. Insurance experts estimate that other losses for improvements average one-third of the losses for dwellings totally destroyed. We shall therefore increase the total losses above by one-third, or $2.02 million. This figure represents average insured loss, insurance systems cost, and uninsured loss on dwellings damaged but not totally destroyed and on other types of improvements.

2. Loss of Life

Although danger to human life is always a definite threat, past experience has shown that relatively few people have been killed in the Santa Monica Mountains by wildfire. As a conservative estimate, we shall assume that an average of one person is killed every other year in Santa Monica wildfires. At $300,000 per human life,* this results in a loss of $150,000 per year. Even if a higher value were assigned, the loss of human life because of wildfire in the Santa Monica Mountains is not economically significant compared with loss of improvements. The possibility of a major disaster involving large loss of life, however, deserves investigation in more detail.

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*This value is representative of the value of human life used by various government agencies.[26]

3. Other Fire-Related Losses

a. Watershed

Due to the stability of the underlying soil and the proximity of the mountains to the ocean, fire-related watershed damage has not been a serious problem in the Santa Monica Mountains. To simplify our analysis we shall assume that watershed damage is directly proportional to the number of acres burned. Based on our work in the Los Padres National Forest,[1] we will assume that, as an upper bound, watershed damages average at most $100 per burned acre.* The analysis in the next section will show that this is an insensitive input: watershed damages are insignificant compared to structural damages. The expected burn rate of 6,000 acres per year therefore results in watershed damages of $600,000 per year.

b. Nonmonetary Losses

Other measurable losses attributable to fire include disruption of communications, transportation, and other public services. These costs have not always been included as direct costs of fire. But they are real costs when services are not performed on time, or not performed at all. We will assume that they average $15-$20 per homeowner per year, or about $500,000 per year.

The nonmonetary costs to society due to fire are difficult to assess. Included in these losses are damages to the aesthetics of the area, wildlife, and recreation. About 4 percent of the Santa Monica Mountains burn each year (6,000 acres out of 150,000 acres). If we assume that the average homeowner in the study area is willing to pay $15-$20 to avoid seeing these 6,000 blackened acres (even if they are not in his immediate area), we can set $500,000 per year for approximate "nonmonetary" damages due to fire. More research needs to be done in assessing the nonmonetary damages to society from wildfire, but for our purposes, sensitivity studies will show that policy selection among protection alternatives is insensitive to the cost assigned this category of loss.

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*Watershed damages in the Matilija watershed were found to average $125 per burned acre for large fires, but most authorities have indicated that watershed damages are a much greater problem in the Matilija area than in the Santa Monica Mountain area. We will assume watershed damages average at most $100 per burned acre in the Santa Monica Mountains.

c. Cost of Fighting Brush Fires

The Los Angeles County and City Fire Departments presently have a combined budget of about $120 million per year. Prorating this total among the number of engine companies in the area gives an estimate of about $8 million per year to protect the Santa Monica Mountains and its inhabitants from fire. Much of this is directed toward the prevention and suppression of normal structural fires, but part of it is spent in maintaining a brush fire fighting capability. City Fire Department officials estimate that, if the threat of brush fires were nonexistent in the City portion of the Santa Monica Mountains, they could save the cost of about 10 trucks and a proportionate number of firemen, about $200,000 per year. Since there are significantly fewer houses in the County portion of the study area, we feel that a greater proportion of the protection task is devoted to brush fires in the County than in the City. We roughly estimate the cost of maintaining a brush fire fighting force in the County to be four times that of the City. This gives a total cost of $1 million per year for the entire Santa Monica region.

The marginal suppression costs of fighting unusually difficult fires, over and above the regular brush fire fighting budget, are estimated to average $200,000 per year.* These costs are not necessarily appropriated after each difficult fire; they may be consumed in the loss of other services and opportunities because certain activities could not be carried out while men and equipment were committed to the fire.

B. Base Case: Cost Plus Loss for Present Fire Protection

Table 6 summarizes the various cost and loss elements for the present system of fire protection. The present system is found to have an annual cost plus loss of $11 million per year. Much of this amount is not recorded in fire department records (for example, the insurance systems costs), but the total does represent the expected annual cost plus loss for the present system of fire protection in the Santa Monica Mountains. This amount will serve as a benchmark in evaluating other alternatives for fire protection.

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*The Chief of the Los Angeles City Fire Department estimated the costs of fighting the Bel Air fire to be $3 million over and above the costs of maintaining the normal fire department operation.[15]

Table 6

EXPECTED ANNUAL COST PLUS LOSS FOR THE PRESENT SYSTEM OF FIRE PROTECTION
(Thousands of Dollars)

Improvements			
Dwellings	$3,000		
Insurance systems cost	2,450		
Uninsured losses	600		
Total loss from destroyed dwellings		$6,050	
Loss of other improvements		2,020	
Total loss of improvements			$ 8,070
Loss of human life			150
Watershed damage			600
Disruption caused by fire			500
Damage to aesthetics, wildlife, recreation			500
Marginal suppression costs			200
Maintenance of brush fire fighting capability			1,000
Program implementation costs			0
Total cost plus loss			$11,020

V ANALYSIS OF THE ALTERNATIVES FOR IMPROVED FIRE PROTECTION

In this section we shall examine three basic approaches to providing improved fire protection for wildland areas: (1) reduction of the number of conflagrations; (2) reduction of the extent of conflagrations; and (3) reduction of the damage caused by conflagrations. These approaches are not intended to be mutually exclusive, but rather are intended to provide a frame of reference for examining specific alternatives.

A. Reduction of the Number of Conflagrations

One approach to wildland fire protection is to reduce the incidence of fires. A number of programs have already been implemented to achieve this goal (programs of prompt detection and initial attack, public education, and the fireproofing of recreation areas). All of these programs are intended to either prevent fires from occurring in the first place or to suppress them in the initial attack before they become large. Of interest is the question of whether these programs should be augmented or whether other new measures (such as closing areas to the public in periods of extreme fire weather) should be implemented to reduce further the number of fires.

Rather than attempting to model how one or some combination of these activities would affect the future pattern of fire damages, our approach will be to hypothesize a 10 percent reduction in the average number of acres burned and homes lost and then to determine the resulting reduction in cost plus loss. If this is found to be a significant reduction compared with the cost to achieve it, then more analysis should be directed toward this alternative.

In assessing the cost plus loss for this alternative, we shall ignore the issue of fuel accumulation. Any fuel buildup which would result from a reduced burn rate may diminish the long-range effectiveness of this alternative because of the demonstrated likelihood that future fires may be more intense due to the increased age and amount of fuel present.[6]

The 10 percent reduction in number of acres burned and homes lost would result in a reduction of $980,000 in damages plus insurance systems costs. Fire-fighting costs would also be reduced by 10 percent ($20,000),

but there would be no change in cost of maintaining the brush fire fighting capability, because there would still be brush fires to fight. Thus, the 10 percent reduction in large fires would result in an expected savings of $1 million per year.

The cost plus loss for this alternative is given in Table 7, where C_1 denotes the cost of implementing the reduction program. We find that any prevention or initial attack program costing less than $1 million per year and resulting in at least a 10 percent reduction in acres burned and houses lost would be economically justified from the standpoint of

Table 7

EXPECTED ANNUAL COST PLUS LOSS DUE TO WILDFIRE
ASSUMING TEN PERCENT REDUCTION IN DAMAGES
(Thousands of Dollars)

Improvements			
Dwellings	$2,700		
Insurance systems cost	2,205		
Uninsured losses	540		
Total loss from destroyed dwellings		$5,445	
Loss of other improvements		1,820	
Total loss of improvements			$ 7,265
Loss of human life			135
Watershed damage			540
Disruption caused by fire			450
Damage to aesthetics, wildlife, recreation			450
Marginal suppression costs			180
Maintenance of brush fire-fighting capability			1,000
Program implementation costs			C_1
Total cost plus loss			$10,020 + C_1

society at large. Thus, for example, since the average cost of a single fireman is about $20,000 it would be economically justifiable to hire a new crew of 50 firemen if their prevention and initial attack efforts could be expected to reduce average fire damage by 10 percent.

B. Reduction of the Extent of Conflagrations

A second strategy in wildland fire protection is to reduce conflagration extent or size. Control of the boundaries of a large fire is accomplished directly by suppression forces and indirectly through fuel management. Large fire suppression includes the massive use of men, aircraft, heavy equipment, and other technological innovations.

Large fires can also be fought indirectly through fuel management. Most fire experts believe that, despite advances in technology, there is little that can be done to control the head of a raging conflagration, except to wait until the fuel is exhausted or until the wind dies out. One approach in fighting large fires is, therefore, to reduce the available fuel before the fire starts. Such fuel management in the Santa Monica Mountains has usually been carried out on a small scale. Relatively narrow fuel breaks have been constructed to give the fire crews access to the area and to provide them with a safe spot to make a stand especially against the flanks of the fire. The high energy release and the long distance spotting of fires make narrow fuel breaks ineffective against the head of a large fire, and for reasons of safety, these fuel breaks may not even be manned by suppression forces. To provide adequate safety to suppression crews usually requires a minimum width of 200 feet.[22] A width of a half-mile may be needed if the break is to be effective in permitting suppression forces to stop the head of a wind-driven fire spreading through long distance spotting.[8,1]

1. Area-Wide Fuel Break System: Purchase Option

Since fuel breaks have been considered at various times for the Santa Monica Mountains, it is of interest to examine their effectiveness on a cost plus loss basis. An extensive fuel break system was considered by the Los Angeles County Fire Department shortly after the 1970 fires.[9]

This system would have stretched about 40 miles in the county portion of the Santa Monica Mountains and would have been one-half mile wide in many sections. Including the secondary fuel breaks envisioned for the system, the plan would have required the acquisition of 20,000 acres in Los Angeles County alone. Extending the system on an equivalent

basis to the city portion of the study area might have required an additional 10,000 acres.*

Average land values in areas where the fuel break would have run are estimated by county authorities to be $5,000 per acre.† Acquisition costs for this system would therefore have been $150 million, or $15 million per year on an annualized basis at 10 percent interest assuming an infinite amortization time.‡ Taxes foregone would have cost $3,750,000 per year, based on a 2.5 percent tax rate. At $65 per acre per year, construction and maintenance costs would have averaged an additional $1,950,000 per year (see Appendix A). The costs of implementing the fuel break system, assuming that the necessary land would be acquired at market value, would therefore have been $20.7 million.

Whether fire crews can stop a raging conflagration at a half-mile wide fuel break depends on several factors, including: availability of crews and equipment, microclimatic conditions, fuel age, and terrain. For purposes of this preliminary analysis, we will assign a 50 percent chance to firemen being able to stop a large fire at a half-mile wide fuel break under severe Santa Ana conditions. Based on our work in the Los Padres National Forest, this is probably a high assessment for the head of a conflagration but low for the flanks.[1]

Based on this assessment of fuel break effectiveness, we shall assume that damages and insurance systems costs would be decreased by one-half under a system of expanded fuel breaks. The cost of maintaining a brush fire fighting capability would remain the same, and there would be a 50 percent reduction in marginal suppression costs.

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*Estimate of Decision Analysis Group.

†Average land values in the city are considerably higher than $5,000 per acre. As shown by our analysis, however, a higher acquisition cost would only make the fuel break system more unattractive from an economic standpoint.

‡We have assumed an infinite time horizon to amortize the investment. Even if the investment were amortized over a finite period, the annual cost of the investment would be about the same (the amortization period would most likely be 20-40 years). For example, the annual cost of a $150 million investment at 10 percent interest, assuming a 30 year amortization period would be $15.91 million per year. The use of an infinite amortization time gives an annual cost of $15 million per year for this investment. The Office of Management and Budget has recommended a 10 percent discount rate for use in evaluating U.S. Government decisions.

The annual cost plus loss for the fuel break alternative is given in Table 8. Compared to the present system of fire protection, the fuel break system is clearly economically unattractive when the land must be purchased at market value. The cost of acquiring and implementing the fuel break system ($20.7 million) is not even approximately balanced by the $5 million savings in damages and marginal suppression costs.

Table 8

EXPECTED ANNUAL COST PLUS LOSS DUE TO WILDFIRE
UNDER AREA-WIDE FUEL BREAK SYSTEM
(LAND ACQUIRED AT MARKET VALUE)
(Thousands of Dollars)

Improvements			
Dwellings	$ 1,500		
Insurance systems cost	1,225		
Uninsured losses	300		
Total loss from destroyed dwellings		$3,025	
Loss of other improvements		1,010	
Total loss of improvements			$ 4,035
Loss of human life			75
Watershed damage			300
Disruption caused by fire			250
Damage to aesthetics, wildlife, recreation			250
Marginal suppression costs			100
Maintenance of brush fire fighting capability			1,000
Program implementation costs			
Taxes foregone	$ 3,750		
Construction and maintenance	1,950		
Purchase of land	15,000		
Total program implementation costs			20,700
Total cost plus loss			$26,710

2. Area-Wide Fuel Break System: Without Purchase

Although we have shown that it is economically unattractive for fire protection agencies to purchase the land necessary for a fuel break, there are other ways that use of the land could be acquired. The land might be acquired jointly by several public agencies to use for fire protection and other purposes such as parks, golf courses, or hiking. Use of the land might also be obtained through offering private owners tax forgiveness.* The question is: How much should the fire protection agencies be willing to pay to acquire use of the land for an area-wide fuel break system?

As shown in Table 9, the cost plus loss for the area-wide fuel break system would be $8 million per year if there were no costs involved in acquiring the land. This compares with a cost of $11 million for the present system of fire protection. Thus, it would be economically justifiable to spend up to $3 million per year ($100 per acre per year) in acquiring use of the necessary land. Taxes on the land average $125 per acre, so it would not be economical to acquire use of the land through programs of total tax forgiveness. However, it would still be worthwhile to investigate acquiring use of the land through partial tax forgiveness. Otherwise, the only way that an area-wide fuel break system could be economically justified would be through donation of the land, either by its owners or by a public agency that had acquired the land for some other public purpose (such as recreation) that is compatible with a fuel break system.

C. Reduction of Conflagration Consequence

A third approach to wildland fire protection is to stress the reduction of damages instead of number of fires or acreage burned. Under this approach the protection effort would be directed toward areas of high value, particularly those with dwellings, flood control structures, recreation facilities, and other improvements. Since local authorities have indicated that watershed damage is of secondary importance, we shall limit our analysis to the protection of dwellings and associated structures. We will begin by examining the various measures that individual homeowners can take to protect their property from fire. In Section V-E

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*At present most affected property owners have agreed to narrow fire breaks on their land, but it is not known how agreeable they would be to one-half mile wide fuel breaks.

Table 9

EXPECTED ANNUAL COST PLUS LOSS DUE TO WILDFIRE
UNDER AREA-WIDE FUEL BREAK SYSTEM
(LAND ACQUIRED AT NO COST)
(Thousands of Dollars)

Improvements			
Dwellings	$1,500		
Insurance systems cost	1,225		
Uninsured losses	300		
Total loss from destroyed dwellings		$3,025	
Loss of other improvements		1,010	
Total loss of improvements			$4,035
Loss of human life			75
Watershed damage			300
Disruption caused by fire			250
Damage to aesthetics, wildlife, recreation			250
Marginal suppression costs			100
Maintenance of brush fire fighting capability			1,000
Program implementation costs			
Construction and maintenance			1,950
Total cost plus loss			$7,960

we shall examine localized programs of fuel modification for particular localities within the Santa Monica Mountains.

There are several steps that can be taken to protect individual homes from fire. The most important are to install fire-retardant roofs and clear dense flammable brush from the immediate surroundings of the house. Overhanging eaves and other openings to the house can also be closed to prevent flying embers from entering the house. Fireproof shutters would

also help, especially on the sides of the house that get direct fire exposure. Other aids include auxiliary pumps for swimming pools, driveway improvements, and elimination of flammable objects from the yard. Programs to train ably bodied citizens to defend their houses during periods of moderate fire exposure would enhance any of these measures.

These measures must be evaluated from the standpoint of the homeowner, since it is the homeowner who must ultimately pay for them. Thus, it is of interest to examine the incentives that the homeowner has in protecting his house from fire. We will focus our attention on roof type and brush clearance, since these were two of the more important factors in the Bel Air fire (see Section III-B-3) and since most of the present incentives are directed toward these measures.

1. Homeowners' Incentives

Each homeowner must decide which measures he will take to protect his home from wildfire. This decision depends on his assessment of the likelihood of a wildfire occurring, his potential losses, his aversion to risk, the costs of implementing the protection measures (including the aesthetics cost of changes in the appearance of the house), associated reductions in insurance surcharge, and existing legal ordinances. Some homeowners in the Santa Monica Mountains have taken expensive and elaborate measures to protect their homes from wildfires, while others have taken only those measures that are legally required. The important point is that each homeowner decides what measures are best for him based on his assessment of the wildfire threat.

a. Legal Incentives

Both the City and County have established ordinances governing brush clearance and roof type in the Santa Monica Mountains. Although there are technical differences in the two ordinances, they both basically require that native brush be cleared in areas within 30 feet of all structures and that brush be thinned and maintained at a height of 3 to 18 inches within 100 feet of all structures. If the homeowner's property does not extend 100 feet from all sides of the house, then it is the responsibility of the neighboring property owner to see that the necessary brush is cleared. Failure to comply with these requirements is a misdemeanor subject to a fine of not more than \$500 and 6 months in jail. If the homeowner does not clear the brush, then the fire agencies can have it done and charge all expenses to the property owner's tax bill. As discussed in a later section, insurance records indicate that 76 percent of the property owners have complied with these ordinances. Fire authorities have said that a principal

reason for not achieving perfect compliance is the difficulty of locating absentee landowners.

It should be noted that the brush ordinances only apply to native brush. A casual examination of the area might indicate that fewer than 76 percent of the homeowners have complied with the brush ordinances, but this is because many residents have replaced the brush with dense ornamental shrubbery. While some species of ornamental shrubs are relatively fire-resistant, other species (e.g., juniper) are highly flammable. Research should be directed toward the role of ornamental shrubbery in the spread or containment of wildfire. Also, since the amount of dead material is important in determining the flammability of native brush,[7] investigation should be directed toward the possibility of pruning native shrubbery as an alternative to requiring the clearance of that shrubbery.

Building codes in both the city and county require that all new roofs be fire retardant. Both codes approve composition, metal, tile, and rock roofs. Untreated shake and shingle roofs are considered unacceptable because of the firebrand problem, but two chemical processes are now available that make shingles more fire retardant. Both processes are recognized by the two codes as rendering shingles fire retardant, but there is doubt on the part of some firemen about the long-term effectiveness of one of the processes, which uses a dip treatment. Tests by Underwriters Laboratory have demonstrated that the alternative process (a pressurized method of application) gives satisfactory long-term results. The Insurance Services Office recognizes the pressurized process but not the dip-treated process as rendering shingles fire retardant. It is not known whether any new roofs have been installed in conflict with the roof-type ordinance, but insurance records show that, of all the houses in the study area, 73 percent have approved roofs (including the pressure-treated, but not dip-treated shingles). Most of the untreated roofs are believed to have been installed prior to the establishment of the ordinances.

b. <u>Economic Incentives</u>

From an economic standpoint, the most attractive alternative to the homeowner is that which results in the least cost plus loss to him as an individual. The homeowner must consider the following economic elements in making this assessment: cost of fire insurance, uninsured losses, and the cost of the protective measures. As before, we will ignore the basic premium and consider only the brush surcharge, since we are not concerned with fires of structural origin.

In order to compare uninsured losses with costs that are incurred annually, we must first determine the probability of the loss occurring in a given year. We then determine what the average annual losses would be over a long period of time, so that all costs and losses can be compared on an annual basis.

For ease of presentation, the following notation is introduced:

$P(x)$ is the probability that the event x occurs

$E(x)$ is the expected or average value of the quantity x

F denotes the event that a house is exposed to wildfire

D denotes the event that a house is destroyed by wildfire

B_n denotes a house with n feet of brush clearance

R_a denotes a house with approved roof

R_u denotes a house with unapproved roof

The probability that the house will be destroyed in a given year is equal to the probability that it will be exposed to wildfire times the probability that it will be destroyed if it is exposed to wildfire. That is,

$$P(D) = P(D|F)\ P(F) \quad .$$

If we assume an average 30-year cycle time between fire exposures, the probability that the house will be exposed to wildfire in a given year is

$$P(F) = 1/30 = 0.033 \quad .$$

As indicated in Section III-C, the probability of destruction given exposure, $P(D|F)$, depends on the type of roof and amount of brush clearance that the house has. We will use the Bel Air statistics to model the dependence on these factors, since the Bel Air statistics are the only data available relating the likelihood of destruction to roof type and brush clearance. As more data becomes available, the burn probabilities obtained from the Bel Air fire should be revised to reflect this new information.

Thus we find from Table 1 that the probability of destruction given exposure for a house with 30 feet of brush clearance and an unapproved roof is

$$P\left(D|B_{30}, R_u, F\right) = 0.495 \quad .$$

The probability that this house will be destroyed in a given year is therefore

$$\begin{aligned} P\left(D|B_{30}, R_u\right) &= P\left(D|B_{30}, R_u, F\right) \times P(F) \\ &= 0.495 \times 0.033 \\ &= 0.0165 \quad . \end{aligned}$$

Assuming a potential \$10,000 uninsured loss, the expected uninsured losses for this house are

$$\begin{aligned} E\left(\text{uninsured loss}|B_{30}, R_u\right) &= 0.0165 \times 10{,}000 \\ &= \$165 \quad . \end{aligned}$$

The uninsured losses for other categories of roof type and brush clearance are calculated in an analogous manner.

The cost to the homeowner of implementing the protective measures depends upon how much brush he elects to clear and whether or

not he decides to have an approved roof installed. The costs of implementing these measures are detailed in Appendices A and B. Briefly, the cost of the brush clearance program is found by multiplying the number or fraction of acres the homeowner elects to clear by the annual cost of having an acre of land cleared ($110 per acre per year at 10 percent interest). Since most of the unapproved roofs in the area are shake or shingle, we assume that the homeowner who elects to convert his roof to a fire retardant one will have a pressure treated shake or shingle roof installed. Therefore, the annualized cost of converting a roof to an approved rating is the cost of having a pressure treated shake or shingle roof installed, or $390 per year at 10 percent interest for a typical 3,000 square foot roof.

Tables 10 and 11 summarize the roof type and brush clearance decision for typical homeowners with a $50,000 home in protection classes 4B and 10B. Here we have assumed that the home presently has 15 feet of clearance and an unapproved roof. The tables show that there is little incentive for having an approved roof installed. From the standpoint of cost plus loss to the homeowner, the homeowner would do best in both protection classes by having an unapproved roof and 100 feet of brush clearance. Having an approved roof installed would increase the cost plus loss to the homeowner in protection class 4B by more than 100 percent--from $289 to $612 per year.

The present surcharge schedule offers some economic incentive for homeowners to have their brush cleared and to have approved roofs installed. However, the incentive appears low in comparison to the effect that these measures have on the probability of the house being destroyed. For example, a 20 percent reduction in surcharge is given to homeowners with approved roofs and 100 feet of brush clearance. In fact, the destruction rate for homeowners in this category was 95 percent less in the Bel Air fire than the rate for homeowners with equivalent brush clearance but unapproved roofs.

It is of interest to examine a revised surcharge schedule in which the rates are set so as to reflect the likelihood of destruction observed in the Bel Air fire. For purposes of convenience we have reproduced the burn probabilities of the Bel Air fire in Table 12 where the brush clearance categories have been adjusted to reflect the categories used by the insurance industry.

In order to determine the surcharge for a given roof type/brush clearance category, we must determine the expected losses and then augment them by the insurance systems cost, as discussed in Section III-C.

Table 10

ECONOMIC CONSIDERATIONS FOR THE HOMEOWNER: THE DECISION OF ROOF TYPE AND BRUSH CLEARANCE FOR PROTECTION CLASS 4B
($50,000 Home; $10,000 Potential Uninsured Loss)

Alternative	Surcharge	Expected Uninsured Loss*	Program Cost	Total Cost
Approved roof, 0-30 foot clearance	$200	$ 81	$390	$671
Approved roof, 30-60 foot clearance	180	18	423	621
Approved roof, 60-100 foot clearance	140	5	485	630
Approved roof, more than 100 foot clearance	80	2	530	612
Unapproved roof, 0-30 foot clearance	250	165	0	415
Unapproved roof, 30-60 foot clearance	225	95	33	353
Unapproved roof, 60-100 foot clearance	175	48	95	318
Unapproved roof, more than 100 foot clearance	100	49	140	289

*Calculations use the destruction rates from the Bel Air fire and assume a probability of exposure in a given year of 1/30.

Table 11

ECONOMIC CONSIDERATIONS FOR THE HOMEOWNER: THE DECISION OF ROOF TYPE AND BRUSH CLEARANCE FOR PROTECTION CLASS 10B
($50,000 Home; $10,000 Potential Uninsured Loss)

Alternative	Surcharge	Expected Uninsured Loss*	Program Cost	Total Cost
Approved roof, 0-30 foot clearance	$640	$ 81	$390	$1,111
Approved roof, 30-60 foot clearance	640	18	423	1,081
Approved roof, 60-100 foot clearance	640	5	485	1,130
Approved roof, more than 100 foot clearance	560	2	530	1,092
Unapproved roof, 0-30 foot clearance	800	165	0	965
Unapproved roof, 30-60 foot clearance	800	95	33	928
Unapproved roof, 60-100 foot clearance	800	48	95	943
Unapproved roof, more than 100 foot clearance	700	49	140	889

*Calculations use the destruction rates from the Bel Air fire and assume a probability of exposure in a given year of 1/30.

Table 12

PROBABILITY THAT A HOUSE OF GIVEN ROOF TYPE AND BRUSH CLEARANCE WILL BE DESTROYED WHEN EXPOSED TO WILDFIRE*

Brush Clearance (feet)	Approved Roofs	Unapproved Roofs
0-30	0.243	0.495
30-60	0.054	0.286
60-100	0.016	0.144
More than 100	0.007	0.148

*Data are from Los Angeles City Fire Department Records of the 1961 Bel Air fire (1,850 homes in the sample).

The expected losses are found as in the previous section--that is, by multiplying the insured value of the house times the probability that it will be destroyed when exposed to wildfire times the probability that it will be exposed to wildfire in a given year. Thus, assuming a 30-year cycle time as before, the expected losses for a $50,000 home with an unapproved roof and 30 feet of brush clearance are

$$E\left(\text{loss}\,|\,B_{30},\ R_u\right) = P\left(D\,|\,B_{30},\ R_u,\ F\right) \times P(F) \times \text{Value of House}$$

$$= 0.495 \times 0.033 \times \$50{,}000$$

$$= \$825 \quad .$$

The insurance systems costs are 45/55 of the expected loss, or $675. Thus, the total surcharge for this house would be $1,500.

Table 13 summarizes the homeowner's decision on roof type and brush clearance under this revised surcharge schedule. Here we have

Table 13

ECONOMIC CONSIDERATIONS FOR THE HOMEOWNER:
THE DECISION OF ROOF TYPE AND BRUSH CLEARANCE
UNDER REVISED INSURANCE SURCHARGE RATES
($50,000 Home; $10,000 Potential Uninsured Loss)

Alternative	Surcharge	Expected Uninsured Loss	Program Cost	Total Cost
Approved roof, 0-30 foot clearance	$ 736	$ 81	$390	$1,207
Approved roof, 30-60 foot clearance	164	18	423	605
Approved roof, 60-100 foot clearance	49	5	485	539
Approved roof, more than 100 foot clearance	21	2	530	553
Unapproved roof, 0-30 foot clearance	1,500	165	0	1,665
Unapproved roof, 30-60 foot clearance	865	95	33	993
Unapproved roof, 60-100 foot clearance	436	48	95	579
Unapproved roof, more than 100 foot clearance	448	49	140	637

not distinguished among protection classes, because the destruction probabilities that we have used do not depend on protection class. One issue that needs further investigation is whether the surcharge should depend on protection class at all. The Bel Air fire has been the worst one to date in terms of homes destroyed, and yet the area burned by the fire was in protection class 4, a relatively good protection class.

The table shows that there are definite incentives under this revised surcharge schedule for homeowners to have both approved roofs and brush clearance. The most attractive option from the standpoint of homeowner's cost plus loss is to have both an approved roof and

from 60 to 100 feet of brush clearance. Such a program would result in a cost plus loss to him of $539 per year, 3 times less than what it would be for an unapproved roof and no brush clearance at all. Due to the small difference in burn probabilities for homes having more than 60 feet of brush clearance, it does not pay under this schedule to have the brush cleared to more than 100 feet. We note that the cost plus loss for the most attractive alternative ($539) is considerably more than for the most attractive under the present surcharge in protection class 4B and considerably less than under 10B. Our revised calculation does not differentiate among protection classes.

We believe that the brush surcharge rates should be set so as to reflect expected losses. On the basis of the Bel Air data, present rates do not meet this criterion. Revising the surcharge schedule will strengthen the incentive for homeowners to protect their property from fire.

2. The Effect of Improving Roofs and Brush Clearance

a. Destruction Rate for the Present Mix of Houses

Before computing the total cost plus loss to society for programs of brush clearance and roof conversion, we will determine the destruction rate for the present mix of houses according to their present brush clearance and roof type. To determine the expected contribution of each category of brush and roof type, we must multiply the probability of destruction given fire exposure by the fraction of houses in that category. The overall destruction rate is the sum of the rates for all categories.

The present distribution of houses for the entire Santa Monica area by brush clearance and roof type is given in Table 14. Data for this table was determined from the Brush Surcharge Books[11] by sampling the number of homes in each category and then determining the appropriate percentages. We will use the destruction probabilities from the Bel Air fire (Table 12) to calculate the overall destruction rate, again because these are the only comprehensive statistics available which correlate roof type and brush clearance with the likelihood of destruction.

Table 14

PRESENT DISTRIBUTION OF HOUSES IN THE SANTA MONICA MOUNTAINS BY ROOF TYPE AND BRUSH CLEARANCE

Brush Clearance (feet)	Approved Roofs	Unapproved Roofs	Total
0-30	0.035	0.004	0.039
30-60	0.072	0.014	0.086
60-100	0.090	0.026	0.116
More than 100	0.536	0.223	0.759
Total	0.733	0.267	1.00

Thus, using the data in Tables 12 and 14, the expected burn rate for the present mix of houses, given fire exposure, is

$$E(\text{destruction rate}|F) = \sum_{i=1,8} P\left(D|c_i,F\right) \times P\left(c_i,F\right)$$

$$= (0.243)(0.035) + (0.054()0.072)$$

$$+ (0.016)(0.090) + (0.007)(0.536)$$

$$+ (0.495)(0.004) + (0.286)(0.014)$$

$$+ (0.144)(0.026) + (0.148)(0.223)$$

$$= 0.060$$

where

c_i = house is in roof type/brush clearance category i.

Thus, if a fire were to sweep through the Santa Monica Mountains, the expected percentage of houses destroyed would be about 6 percent. In some areas the destruction rate would be greater, in others less, depending on local conditions. But, if a fire were to sweep through the entire area, we should expect an average of 6 percent, or about 1,800 houses, to be destroyed. For purposes of reference, the 6 percent destruction rate compares with a 22 percent rate for the Bel Air fire. The difference in the two destruction rates is because a much greater proportion of houses have approved roofs and good brush clearance today than they did in Bel Air in 1961.

The 6 percent destruction rate* is conditional on exposure, that is on a fire going through the area. To determine the burn rate,† we must multiply the 6 percent conditional rate times the probability that the area will be exposed to wildfire in a given year. Assuming a 30-year cycle time between major fires in a particular housing area, the probability that the area will be exposed to fire in a given year is 1/30 or 0.033. Thus, the average annual burn rate for the present mix of houses is

$$\begin{aligned} E(\text{burn rate}) &= E(\text{destruction rate} \mid \text{fire}) \times P(\text{fire}) \\ &= 0.060 \times 0.033 \\ &= 0.002 \quad . \end{aligned}$$

---

*We use the term "destruction rate" to describe the expected fraction of homes destroyed when a wildfire burns through a given area. Therefore, the destruction rate equals the probability that a particular home selected in the area will be destroyed.

†The burn rate is the expected fraction of homes destroyed in an area in a given year, given the uncertainty as to whether the area will experience a wildfire.

The expected number of houses burned per year is therefore:

$$E(\text{houses burned}) = E(\text{burn rate}) \times \text{number of houses}$$

$$= 0.002 \times 30{,}000$$

$$= 60 \text{ houses per year} \quad .$$

We note that the burn rate of 60 houses per year is the same as the historical rate documented in Section III-B-1. Thus, our assumption of a 30-year cycle time appears to be valid for the area as a whole.

b. <u>The Effect of More Brush Clearance</u>

As shown in Table 14, 24 percent of the homeowners in the area presently have brush clearances of less than 100 feet. If all parties concerned were to clear their brush to the required distance, leaving roof type the same, then the new distribution of houses by roof type and brush clearance would be as in Table 15. The destruction rate for this case would therefore be

$$E\left(\text{destruction rate} \middle| B_{100}, F\right) = (0.007)(0.733) + (0.148)(0.267)$$

$$= 0.045 \quad .$$

The expected number of houses destroyed each year, assuming a 30-year cycle time, is therefore

$$E(\text{homes destroyed}) = 0.046 \times 0.0333 \times 30{,}000$$

$$= 45 \text{ houses} \quad .$$

Thus 15 (= 60 - 45) houses could be saved on the average if all brush were cleared to 100 feet.

Table 15

DISTRIBUTION OF HOUSES IN THE SANTA MONICA MOUNTAINS IF ALL HOUSES WERE TO HAVE 100-FOOT BRUSH CLEARANCE

Brush Clearance (feet)	Approved Roofs	Unapproved Roofs
0-30	0.000	0.000
30-60	0.000	0.000
60-100	0.000	0.000
More than 100	0.733	0.223

The cost plus loss for the case of complete brush clearance is given in Table 16. Here the damages to improvements have been adjusted to reflect the new burn rate of 45 houses per year. The cost of clearing the necessary brush has been calculated for each distance category and summed to give an overall clearance cost, according to the methods of Appendix A.* The table shows that the cost plus loss for a program of 100 foot brush clearance is $9.6 million per year, or $1.4 million less than the present system of fire protection. The program implementation costs of $604,000 are more than offset by the $2.0 million reduction in damages to improvements.

c. The Effect of Approved Roofs

Twenty-seven percent of the homeowners presently have unapproved roofs. If all homeowners were to convert their roofs to approved roofs, then the distribution of houses by roof type and brush clearance

*In establishing the brush clearance costs for homeowners in the various categories, we have assumed that the brush is presently cleared to the mid-point of the respective category (15 feet for the 0-30 foot category, 45 feet for the 30-60 foot category, and 80 feet for the 60-100 foot category).

Table 16

ANNUAL EXPECTED COST PLUS LOSS DUE TO WILDFIRE
IF ALL HOUSES HAD 100-FOOT BRUSH CLEARANCE
(Thousands of Dollars)

Improvements			
Dwellings	$2,250		
Insurance systems cost	1,841		
Uninsured losses	450		
Total loss from destroyed dwellings		$4,541	
Loss of other improvements		1,513	
Total loss of improvements			$6,054
Loss of human life			150
Watershed damage			600
Disruption caused by fire			500
Damage to aesthetics, wildlife, recreation			500
Marginal suppression costs			200
Maintenance of brush fire fighting capability			1,000
Program implementation			
1,170 houses with 0-30 foot clearance now	$ 164		
2,580 houses with 30-60 foot clearance now	283		
3,480 houses with 60-100 foot clearance now	157		
Total program implementation costs			604
Total cost plus loss			$9,608

would be as in Table 17. The expected destruction rate for this case would be

$$E\left(\text{destruction rate} \middle| R_a, F\right) = (0.243)(0.039) + (0.054)(0.086)$$

$$+ (0.016)(0.116) + (0.007)(0.759)$$

$$= 0.021 \quad .$$

Thus the destruction rate for the situation of all approved roofs would be one-third of the 0.060 rate for the present mix of houses. Assuming a 30-year cycle time, the average burn rate for the case of all approved roofs is therefore:

$$E(\text{burn rate}) = 0.021 \times 0.033 \times 30{,}000$$

$$= 21 \text{ houses per year} \quad .$$

Table 17

DISTRIBUTION OF HOUSES IN THE SANTA MONICA MOUNTAINS
IF ALL HOUSES HAD APPROVED ROOFS

Brush Clearance (feet)	Approved Roofs	Unapproved Roofs
0-30	0.039	0.000
30-60	0.086	0.000
60-100	0.116	0.000
More than 100	0.759	0.000

Table 18 gives the cost plus loss for the case of all approved roofs. The calculation assumes a burn rate of 21 houses per year, and uses the roof conversion costs given in Appendix B. The cost plus loss for this case is $8.9 million or $2.1 million less than the present system of fire protection.

Table 18

ANNUAL EXPECTED COST PLUS LOSS DUE TO WILDFIRE
IF ALL HOUSES HAD APPROVED ROOFS
(Thousands of Dollars)

Improvements			
Dwellings	$1,050		
Insurance systems cost	859		
Uninsured losses	210		
Total loss from destroyed dwellings		$2,119	
Loss of other improvements		706	
Total loss of improvements			$2,825
Loss of human life			150
Watershed damage			600
Disruption caused by fire			500
Damage to aesthetics, wildlife, recreation			500
Marginal suppression costs			200
Maintenance of brush fire fighting capability			1,000
Program implementation cost			
8,010 roofs at $390/roof/year			3,124
Total cost plus loss			$8,899

d. <u>The Effect of Approved Roofs and More Brush Clearance</u>

Our analysis has shown that it would be economically justifiable from the standpoint of society at large to implement programs that required either the brush to be cleared or to have approved roofs put on all houses. It is therefore of interest to examine the economic implications of requiring all houses to have <u>both</u> 100 feet brush clearance and approved roofs. From Table 12 we find that, if all houses had satisfactory brush clearance and approved roofs, the destruction rate given a fire would be 0.007, or less than 1 percent. Assuming a 30 year cycle time, the expected number of houses burned per year would therefore be

$$E\left(\text{burn rate} \middle| B_{100}, R_a\right) = 0.007 \times 0.033 \times 30{,}000$$

$$= 7 \text{ houses per year} \quad .$$

The cost of implementing the program would be the cost of having the appropriate homeowners clear their brush and/or convert their roofs, or \$604,000 + \$3,124,000 = \$3,728,000 per year.

The cost plus loss for the case of all approved roofs and 100 feet brush clearance is given in Table 19. From the standpoint of society at large this is the most attractive alternative. The cost plus loss is \$7.6 million or \$3.4 million less than that for the present system of fire protection. The program implementation costs to society of \$3.7 million are more than offset by the reduction in damages of \$7.1 million per year.

D. <u>Jointly Applied Alternatives</u>

Of the alternatives thus far examined, we have found that the one of requiring both approved roofs and 100 feet of brush clearance is the most attractive. It is of interest to see if the total cost plus loss to society can be further reduced by augmenting these measures with other protection measures. For example, one possibility is to implement a new prevention program in conjunction with a program requiring approved roofs and 100 feet of brush clearance.

We found in the previous section that the average annual burn rate would be reduced from 60 to 7 houses per year if all houses had approved roofs and 100 feet of brush clearance. As shown in Table 19, the total

Table 19

ANNUAL EXPECTED COST PLUS LOSS DUE TO WILDFIRE
IF ALL HOUSES HAD APPROVED ROOFS
AND 100 FOOT BRUSH CLEARANCE
(Thousands of Dollars)

Improvements			
Dwellings	$ 350		
Insurance systems cost	286		
Uninsured losses	70		
Total loss from destroyed dwellings		$706	
Loss of other improvements		235	
Total loss of improvements			$ 941
Loss of human life			150
Watershed damage			600
Disruption caused by fire			500
Damage to aesthetics, wildlife, recreation			500
Marginal suppression costs			200
Maintenance of brush fire fighting capability			1,000
Program implementation			
Brush clearance	$ 604		
Roof conversion	3,124		
Total program implementation costs			3,728
Total cost plus loss			$7,619

losses incurred under a burn rate of 7 houses per year are $2.7 million. Thus, even if the added alternative were completely effective in eliminating wildfire, the most that it could reduce damages by would be $2.7 million. It is unlikely that any program could completely eliminate wildfire, but this number does provide an upper bound on the worth of implementing a second alternative, assuming that all houses already had approved roofs and 100 feet of brush clearance.

If a new prevention program were implemented that could reduce conflagration incidence and damage by 10 percent, then annual losses would be reduced by $270,000 per year, assuming that all houses had approved roofs and 100 feet of brush clearance. This savings is equivalent to the annual cost of 14 firemen. If it is felt that a prevention program costing $270,000 per year would result in less than a 10 percent reduction in the number of conflagrations, then it would not be economically justifiable to implement that preventive program.

We found in Section V-B-2 that the equivalent annual cost of constructing and maintaining an area-wide fuel break system, exclusive of acquisition costs, would be $2 million per year. Assuming that the fuel break system was able to reduce average conflagration extent and damages by one-half, we can see it would not be justifiable to build one even if the land were obtained free. The annual construction costs of $2 million would not be balanced by the $1.4 million reduction in expected annual damages.

It appears that the losses would be so low under the alternative of approved roofs and 100 foot brush clearance that it might be difficult to find a cost-effective alternative to reduce the losses further.

E. Comparison of Alternatives for the Entire Area

Figure 3 gives a graphical comparison of the cost plus loss to society for each of the alternatives studied. It is evident from the graph that private homeowner actions are the most attractive from the standpoint of society at large. Of all the alternatives examined, the one of clearing brush to 100 feet and installing approved roofs is the most attractive. This alternative would reduce the cost plus loss due to fire by nearly one-third. We will therefore examine this alternative in more detail in order to understand its implications for particular subareas in the Santa Monica Mountains.

F. Protection of Localities

Our analysis has thus far used average values for the entire Santa Monica Mountain region. However, many areas differ from the average, and it is of interest to evaluate some of the more promising alternatives in the context of particular localities within the Santa Monica Mountains. We will focus this analysis on two particular subareas: (1) Mandeville Canyon and (2) Monte Nido.

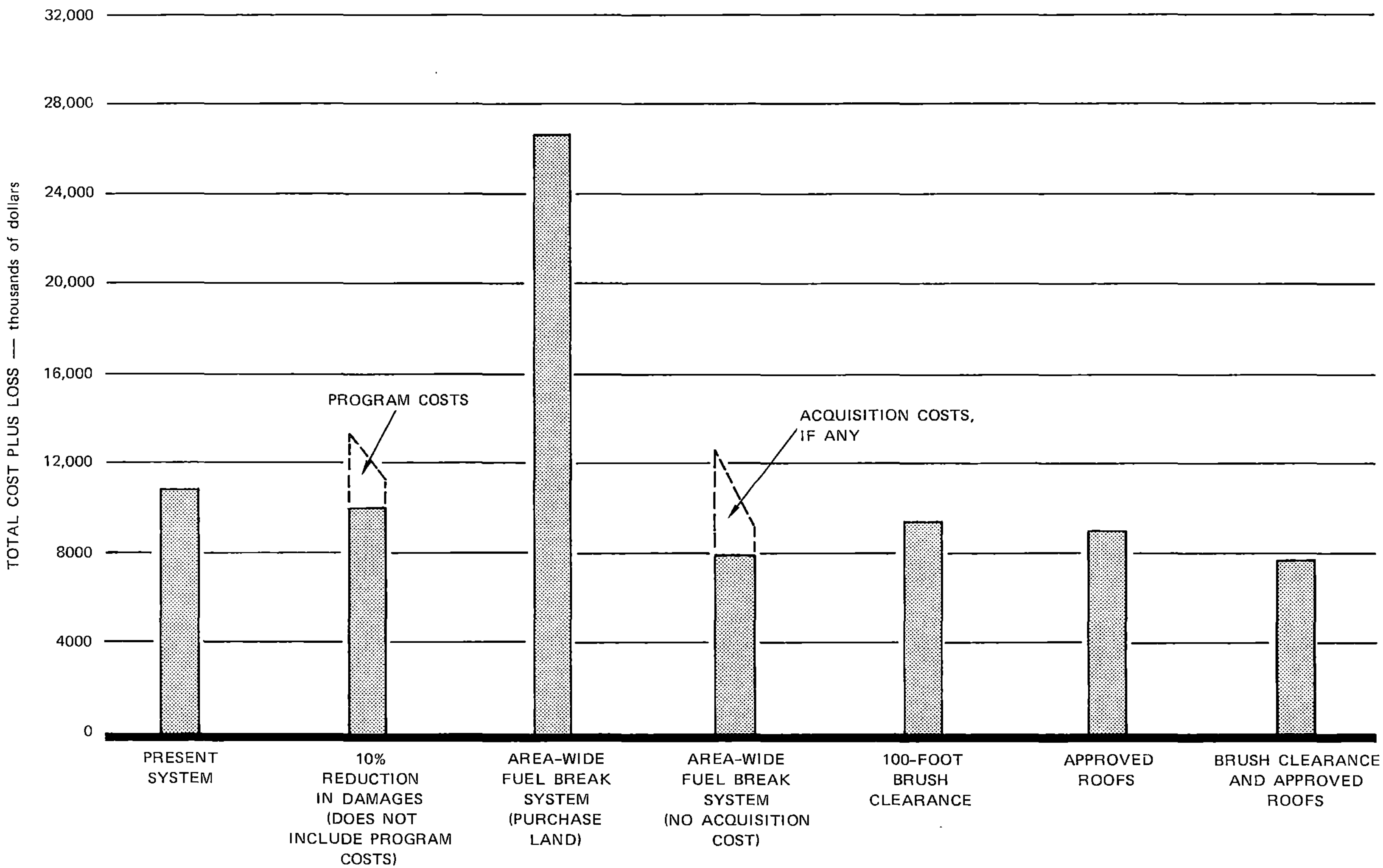

FIGURE 3 COMPARISON OF ALTERNATIVES FOR THE ENTIRE AREA

Our analysis will follow the same format just developed: namely, calculation of the expected burn rate for the particular program and then comparison of the reduction in damages with the cost of implementing the program. Since the subareas are relatively small, there will only be minor changes in some of the lesser cost and damage categories, such as watershed damages and marginal suppression costs. Therefore, we will limit our analysis to structural damages and the cost of implementing the alternative under consideration. Other cost and damage categories are assumed to be invariant to the various alternatives.

1. Mandeville Canyon

There are 1,180 houses in the brush area of Mandeville Canyon.* According to tax assessors and real estate personnel, property values range from more than $100,000 per house in the lower part of the canyon to around $60,000 in the upper part. The tax assessor's office says that about 50 to 60 percent of the total market value is land. Thus, the average structure in the area is worth approximately $40,000-$50,000. Assuming that insurable contents are worth $10-$20,000 per house, we assign a value of $60,000 to the average house plus contents in Mandeville Canyon.

a. Base Case

The present distribution of houses by roof type and brush clearance is given in Table 20(a). The expected destruction rate, given a fire, is calculated as before and is found to be 0.075. This compares to a destruction rate of 0.06 for the entire area, indicating that the fire hazard in terms of destruction rate is 25 percent greater in Mandeville Canyon than in the Santa Monica Mountains as a whole. The expected number of houses burned per year in Mandeville Canyon, assuming a 30-year cycle time, is therefore:

$$E(\text{burn rate}) = 0.075 \times 0.033 \times 1{,}180 = 2.95 \text{ houses/year} \quad .$$

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*Data are taken from Brush Surcharge Book, available from Insurance Services Office. Unless otherwise noted, all data for Mandeville Canyon and Monte Nido are taken from this source.

Table 20

DISTRIBUTION OF HOMES IN MANDEVILLE CANYON:
AT PRESENT AND UNDER POSSIBLE ALTERNATIVES

Brush Clearance (feet)	Approved Roofs	Unapproved Roofs	Total Roofs
	(a) Present Distribution		
0-30	0.005	0.003	0.008
30-60	0.036	0.024	0.060
60-100	0.061	0.041	0.102
More than 100	0.466	0.364	0.830
Total	0.568	0.432	1.0
	(b) Distribution of Homes if All Homes Had 100 Foot Brush Clearance		
0-30	0.000	0.000	
30-60	0.000	0.000	
60-100	0.000	0.000	
More than 100	0.568	0.432	
	(c) Distribution of Homes if All Homes Had Approved Roofs		
0-30	0.008	0.000	
30-60	0.060	0.000	
60-100	0.102	0.000	
More than 100	0.830	0.000	

As shown in Table 21, the losses under a burn rate of 2.95 houses/year are $469,000 per year. Since the present system of fire protection is already in effect, no new costs are incurred for the base case, and hence its cost plus loss is $469,000 per year.

Table 21

ANNUAL COST PLUS LOSS OF STRUCTURAL LOSSES AND IMPLEMENTATION COSTS DUE TO WILDFIRE IN MANDEVILLE CANYON FOR PRESENT MIX OF HOUSES

Improvements			
Dwellings	$177,000		
Insurance systems cost	145,000		
Uninsured losses	30,000		
Total loss from destroyed dwellings		$352,000	
Loss of other improvements		117,000	
Total loss of improvements			$469,000
Program implementation			
Brush clearance	$ 0		
Roof conversion	0		
Total structural losses and implementation costs			469,000

b. Programs of Brush Clearance and Roof Conversion

The expected burn rate for programs requiring brush clearance and/or approved roofs is calculated exactly as before. That is, we first determine the new distribution of houses by roof type and brush clearance, given the particular program, and then calculate the burn rate and resultant damages. Rather than repeat these calculations, we will limit the presentation to giving the revised mix of homes (Table 20) and the resultant cost plus loss for the present program and each alternative (Table 22).

Table 22

ANNUAL COST PLUS LOSS DUE TO WILDFIRE FOR HOMEOWNERS IN MANDEVILLE CANYON
UNDER PROGRAMS OF BRUSH CLEARANCE AND/OR ROOF CONVERSION

	Present Mix (burn rate = 2.95*)	100-Foot Brush Clearance (burn rate = 2.67*)	Approved Roofs (burn rate = 0.49*)	Brush Clearance and Approved Roofs (burn rate = 0.28*)
Loss of dwellings	$177,000	$160,000	$ 30,000	$ 17,000
Insurance systems cost	145,000	131,000	24,000	14,000
Uninsured losses	30,000	27,000	5,000	3,000
Loss of other improvements	117,000	106,000	20,000	11,000
Cost of brush clearance	0	15,000	0	15,000
Cost of roof conversion	0	0	199,000	199,000
Total structural losses and implementation costs	$469,000	$439,000	$278,000	$259,000

*Burn rate in houses per year.

Table 22 shows that homeowners in Mandeville Canyon would benefit by clearing brush and installing approved roofs. Any program that requires either brush to be cleared or approved roofs to be installed will cost less to implement than the expected damages. The most attractive alternative from the standpoint of society is to require both approved roofs and 100 foot brush clearance. Such a program would reduce the average burn rate from 2.95 houses per year to 0.28 houses per year and reduce annual cost plus loss due to fire by 45 percent.

2. Monte Nido

The subdivision of Monte Nido differs in many respects from Mandeville Canyon. It is much smaller, located in a relatively isolated area, and more representative of the areas in the county portion of the Santa Monica Mountains. There are 215 houses in the subdivision. Property values range from \$35-\$80,000 per house, but tax assessors estimate the average house in the area (excluding land) to have a current value of \$25-\$30,000. Assuming that the insurable contents of these homes are worth \$10-\$15,000, we assign an average value of the house and contents in Monte Nido of \$40,000.

a. Base Case and Alternatives of Damage Reduction

Table 23 shows the present distribution of houses in the area by roof type and brush clearance plus what the distributions would be if the various homeowner defense options were exercised. These distributions were used to calculate the destruction rate and resultant damages for the various alternatives, and the resultant cost plus loss calculations are given in Table 24. The table shows that requiring all houses to have either 100 foot brush clearance or approved roofs or both would result in a lower cost plus loss to society than the present systems of fire protection, but the difference is not as great as in Mandeville Canyon. The difference between the most attractive alternative (both approved roofs and brush clearance) and the present system is only \$7,500. The reason that the difference is so small is that there are only 215 houses in the area, and most of them (76 percent) already have satisfactory brush clearances and roof types.

Table 23

DISTRIBUTION OF HOMES IN MONTE NIDO:
AT PRESENT AND UNDER POSSIBLE ALTERNATIVES

Brush Clearance (feet)	Approved Roofs	Unapproved Roofs	Total Roofs
	(a) Present Distribution		
0-30	0.033	0.000	0.033
30-60	0.046	0.000	0.042
60-100	0.084	0.009	0.093
More than 100	0.763	0.070	0.833
Total	0.921	0.079	1.0
	(b) Distribution of Homes if All Homes Had 100-Foot Brush Clearance		
0-30	0.000	0.000	
30-60	0.000	0.000	
60-100	0.000	0.000	
More than 100	0.921	0.079	
	(c) Distribution of Homes if All Homes Had Approved Roofs		
0-30	0.033	0.000	
30-60	0.042	0.000	
60-100	0.093	0.000	
More than 100	0.833	0.000	

Table 24

ANNUAL COST PLUS LOSS DUE TO WILDFIRE FOR HOMEOWNERS IN MONTE NIDO
UNDER PRESENT CONDITIONS AND WITH APPROVED ROOFS AND/OR BRUSH CLEARANCE

	Present Mix (burn rate = 0.20*)	100-Foot Brush Clearance (burn rate = 0.13*)	Approved Roofs (burn rate = 0.12*)	Brush Clearance and Approved Roofs (burn rate = 0.05*)
Loss of dwellings	$ 8,200	$ 5,200	$ 5,000	$ 2,000
Insurance systems costs	6,700	4,300	4,100	1,600
Uninsured losses	2,000	1,300	1,300	500
Loss of other improvements	5,600	3,600	3,500	1,400
Cost of brush clearance	0	2,900	0	2,900
Cost of roof conversion	0	0	6,600	6,600
Total structural losses and implementation costs	$22,500	$17,300	$26,500	$15,000

*Burn rate in houses per year.

b. Local Fuel Break

Although it is generally recognized that an area-wide fuel break system is not economically justifiable, some authorities have suggested constructing fuel breaks in localities of high value. Monte Nido would seem to be a candidate for such a fuel break, since it is located in a relatively isolated area traversed by fires in the past.

For purposes of demonstration, we will consider a 500 foot wide fuel break to be built completely around Monte Nido. The subdivision is approximately one mile in diameter, which means the fuel break would cover 190 acres. At an annual cost of $65 per acre per year, it would cost $12,350 per year to clear and maintain the necessary land.

As shown the expected improvements damage due to fire in Monte Nido is currently $22,500 per year. If we assume that the fuel break could cut damage in half, then the structural damages for the local fuel-break alternative would be $11,250 per year, or almost exactly what it would cost to clear and maintain the necessary land.

A localized fuel break around Monte Nido would seem to be a marginal alternative from the standpoint of cost plus loss to society. If use of the land had to be acquired through purchase or leasing arrangements, then the fuel break would clearly be uneconomical, even if it could prevent half the fires from going through Monte Nido. If we assume that the fuel break could keep all wildfires from entering the subdivision, it would result in a savings to society of not more than $22,500 minus $12,350, or $10,150 per year. The net savings would be reduced from this amount by the cost of acquiring use of the land.

VI SENSITIVITY ANALYSIS

The analysis of the previous sections depends on many assumptions and on the specific numbers used as inputs. In many cases these numbers are uncertain, and we wish to determine whether these uncertainties have a significant effect on our conclusions. In this section we shall examine the sensitivity of our findings to changes in assumptions and input values in our analysis of alternative fire protection policies. The sensitivity analysis will prove useful in determining the range of conditions over which our conclusions are valid and in determining which aspects of the model need refinement.

A. Cycle Time

Cycle time is an important parameter because it gives the probability that a house will be exposed to wildfire in a given year. Based on statistics for the overall area, we have assumed a cycle time of 30 years, which gives a probability of exposure of 1/30 or 0.033. Because of changing population and building patterns within the area, it may be appropriate to use a different cycle time.

Figure 4 shows the effect of varying the cycle time from 10 to 70 years. Here we have limited our analysis to the present system of fire protection and to the three alternatives requiring homeowner action. All other parameters have been kept at their nominal values.

As long as the cycle time is less than 50 years, the most attractive alternative from the standpoint of society at large is that of requiring both approved roofs and 100 feet of brush clearance. This alternative is even more attractive than indicated by our nominal analysis if the cycle time is less than 30 years. For example, at a cycle time of 10 years the difference in cost plus loss between the present system and that of requiring both approved roofs and 100 feet of brush clearance is 65 percent, compared with a 31 percent difference for a 30-year cycle time. On the other hand, if the cycle time is over 50 years, we find that the threat of wildfire is reduced to such a level that it is not economically justifiable to require measures of roof conversion and added brush clearance.

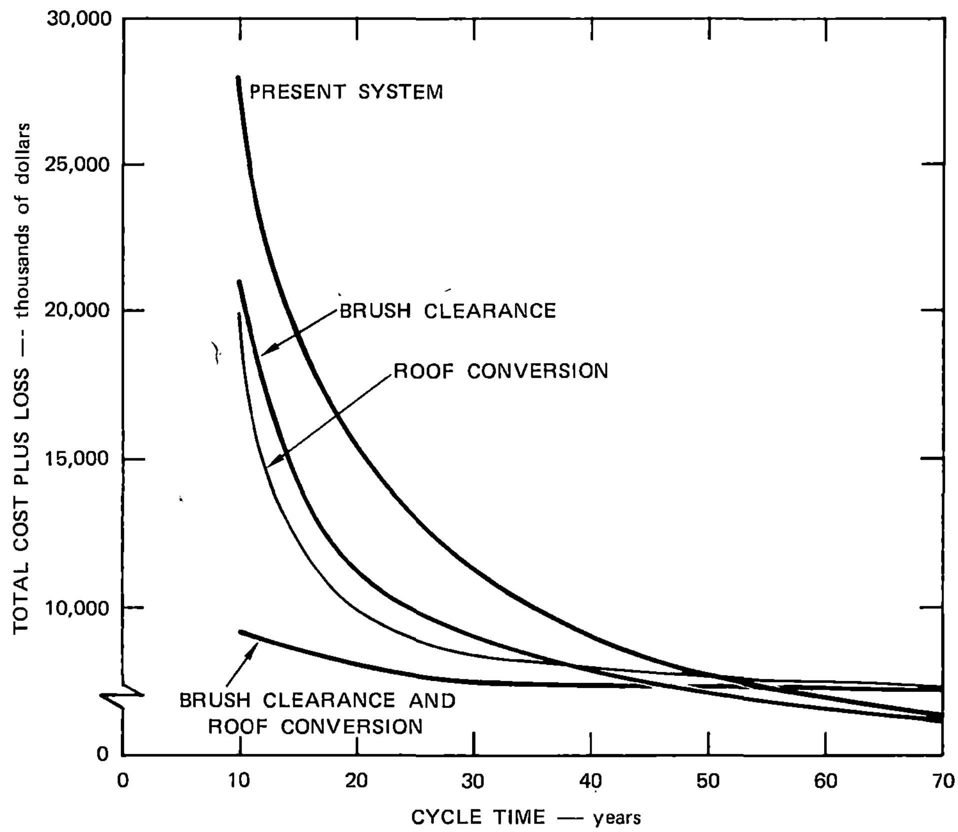


FIGURE 4 SENSITIVITY TO CYCLE TIME

B. Bel Air Statistics

One of the principal assumptions of our analysis was that we could use the statistics from the Bel Air fire to determine the probabilities of destruction given exposure for houses of different roof type and brush clearance. We made this assumption because comparable statistics were not available for other fires. We will now examine how critical this assumption was to our analysis.

The probabilities of destruction, given exposure, are specified for each category of brush clearance and roof type (eight categories in all). We will vary the brush clearance and roof type probabilities independently so as to ascertain the effect of changing the dependency of destruction on either factor.

To examine the dependency on brush clearance, we will consider the two sets of burn probabilities in Table 25. Here we have used our nominal values from the Bel Air statistics for brush clearance categories of

Table 25

PROBABILITIES OF DESTRUCTION GIVEN EXPOSURE
FOR DIFFERENT DEPENDENCIES ON BRUSH CLEARANCE

(a) Houses with brush clearance of less than 60 feet are half as likely to be destroyed compared with nominal case.

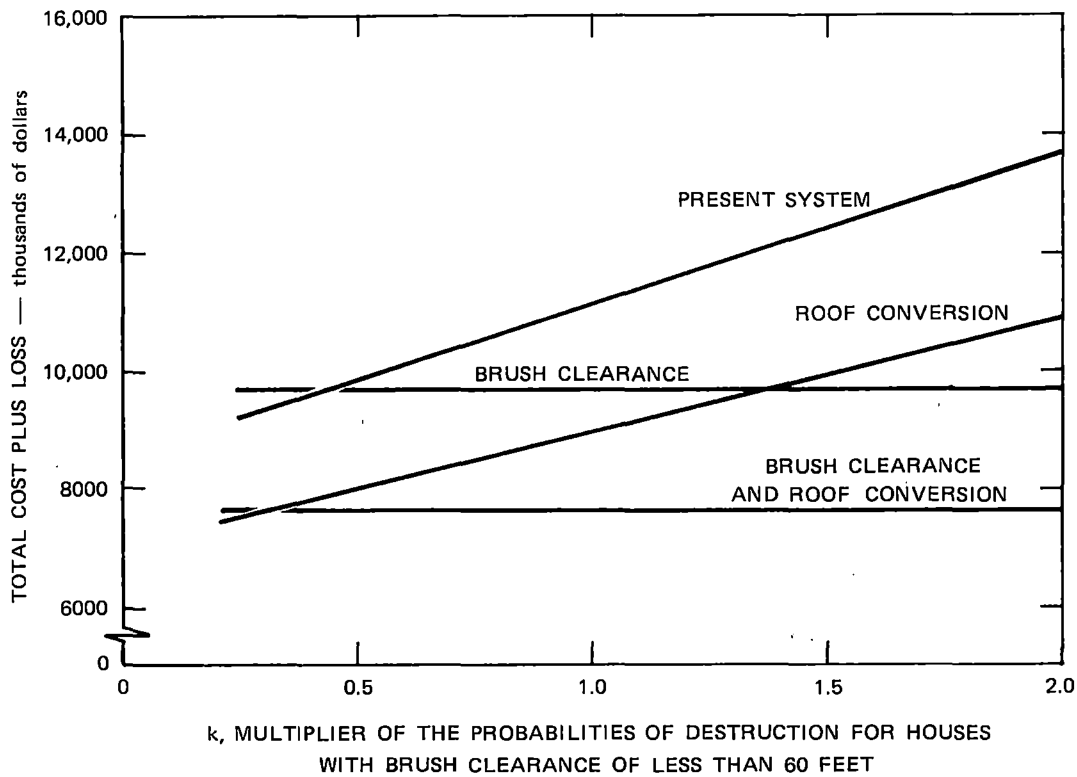
Brush Clearance (feet)	Approved Roof	Unapproved Roof
0-30	0.122	0.248
30-60	0.027	0.143
60-100	0.016	0.144
More than 100	0.007	0.148

(b) Houses with brush clearance of less than 60 feet are twice as likely to be destroyed compared with nominal case.

Brush Clearance (feet)	Approved Roof	Unapproved Roof
0-30	0.486	0.990
30-60	0.108	0.572
60-100	0.016	0.144
$>$ 100	0.007	0.148

greater than 60 feet, but have changed the probabilities for brush clearances of less than 60 feet. Matrix (a) is set so that the low brush clearances are half as likely to burn as assumed for our nominal case. The entries of matrix (b) are set so that the houses with low brush clearance are twice as likely to burn.

Figure 5 shows how the cost plus loss of the four principal alternatives is affected by changing the burn probabilities to reflect different dependencies on brush clearance. Over the range of probabilities tested, the alternative of requiring both brush clearance and roof conversion is



*Probabilities remain at nominal values for houses with brush clearances of greater than 60 feet. See Table 25 for actual probabilities investigated.

FIGURE 5 SENSITIVITY TO THE PROBABILITIES OF DESTRUCTION, GIVEN EXPOSURE, FOR HOUSES WITH BRUSH CLEARANCE OF LESS THAN 60 FEET*

the most attractive. Only if the likelihood of destruction for houses with little brush clearance is dropped to 30 percent of what it was in the Bel Air fire, would our findings change; and in that case it would be most attractive to require just roof conversion. If the probabilities of destruction were greater for houses with minimal brush clearance than we assumed them to be, then the alternative of requiring both brush clearance and roof conversion becomes even more attractive, relative to the present system of fire protection.

To examine the dependence of our results on changes in the probabilities of destruction for different categories of roof type, we will consider the two sets of burn proabilities in Table 26. Matrix (a) represents the case in which houses with unapproved roofs are half as likely to burn as in the Bel Air fire; and matrix (b) gives the case for which houses with unapproved roofs are twice as likely to burn.

Table 26

PROBABILITIES OF DESTRUCTION GIVEN EXPOSURE
FOR DIFFERENT DEPENDENCIES ON ROOF TYPE

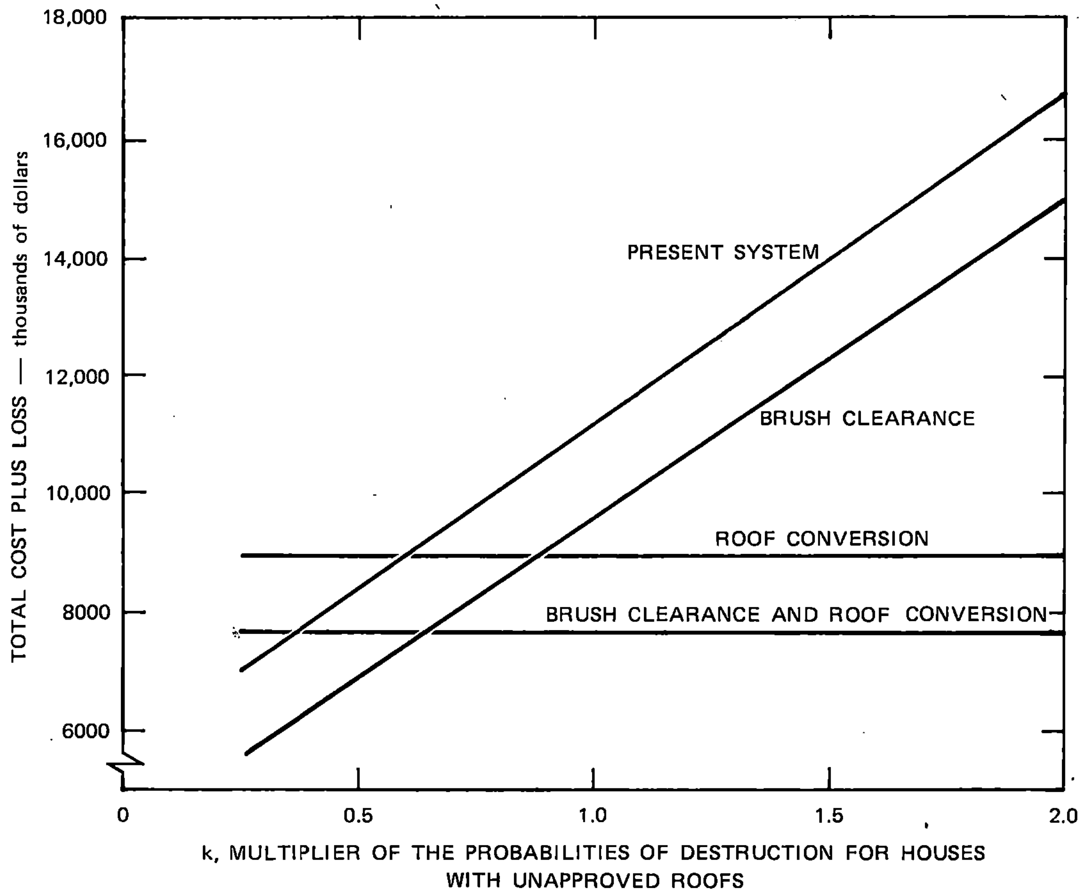
(a) Houses with unapproved roofs are half as likely to be destroyed compared to nominal case.

Brush Clearance (feet)	Approved Roof	Unapproved Roof
0-30	0.243	0.248
30-60	0.054	0.143
60-100	0.016	0.072
> 100	0.007	0.074

(b) Houses with unapproved roofs are twice as likely to be destroyed compared to nominal case.

Brush Clearance (feet)	Approved Roof	Unapproved Roof
0-30	0.243	0.990
30-60	0.054	0.572
60-100	0.016	0.288
> 100	0.007	0.296

Figure 6 shows the effect of changing the burn probabilities to reflect different dependencies on roof type. The figure shows that if houses with unapproved roofs are at least 70 percent as likely to be destroyed as indicated by the Bel Air statistics, then the alternative of requiring both brush clearance and approved roofs is the most attractive. Otherwise, the most attractive alternative is to require brush clearance alone.



*Probabilities remain at nominal values for houses with approved roofs.
See Table 26 for actual probabilities investigated.

FIGURE 6 SENSITIVITY TO THE PROBABILITIES OF DESTRUCTION, GIVEN EXPOSURE, FOR HOUSES WITH UNAPPROVED ROOFS*

C. Housing Values

We defined the value of a house to include the insurable value of the structure and contents, but not land, Public records can be obtained to determine the value of recent real estate sales, but they do not show what portion of the sale was land. Nor is it possible to easily determine the market value of contents for each house.

Figure 7 shows how our results depend on housing values. The figure shows that as long as average housing values in the area are greater than $28,000 per house, the combined approved roof and brush clearance alternative is most attractive. If the average value is more than our nominal value of $50,000 per home, then the combined alternative is even more attractive than indicated by our analysis.

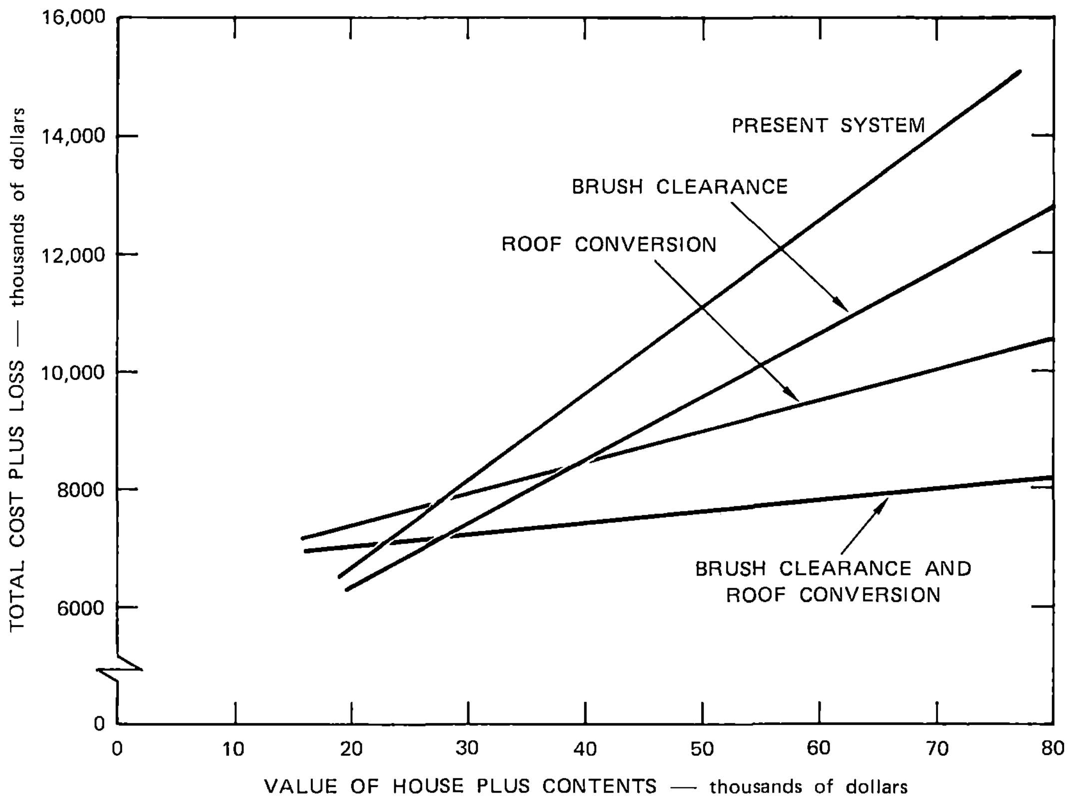


FIGURE 7 SENSITIVITY TO HOUSING VALUES

D. Uninsured Losses

Our damage category of uninsured loss is intended to include property losses not covered by insurance as well as the intangible losses (such as psychological trauma) that are incurred in a fire loss. We have assumed that these losses average $10,000 for homeowners who lose their houses to fire. But this is an arbitrary assignment and many homeowners might assign a much different cost than $10,000 to their potential uninsured losses.

Figure 8 shows the sensitivity of total cost plus loss to changes in the average uninsured loss per homeowner. Here we have varied the potential uninsured losses from $0 to $100,000 and kept all other parameters at their nominal values. The figure shows that the alternative of requiring both brush clearance and roof conversion is the most attractive for all values of potential uninsured loss.

Since uninsured losses are a partial measure of what a homeowner would be willing to forego to avoid fire, the figure also shows that inclusion of risk aversion into our analysis would have only strengthened the case for requiring brush clearance and roof conversion. The effect of

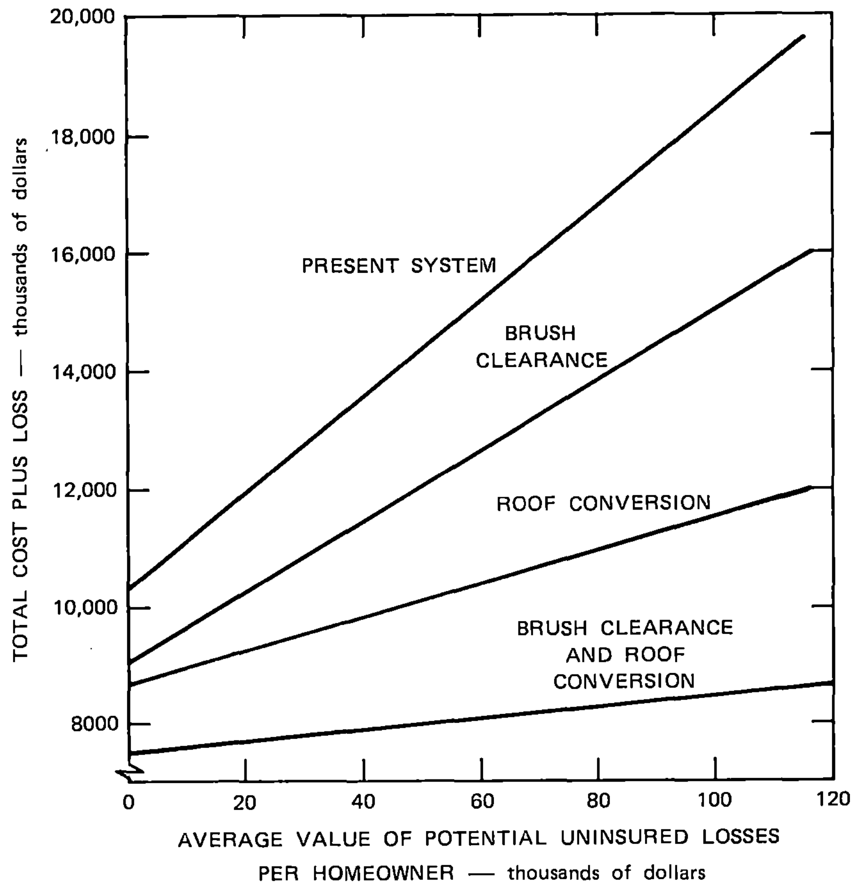


FIGURE 8 SENSITIVITY OF TOTAL COST PLUS LOSS TO VALUE OF UNINSURED LOSS

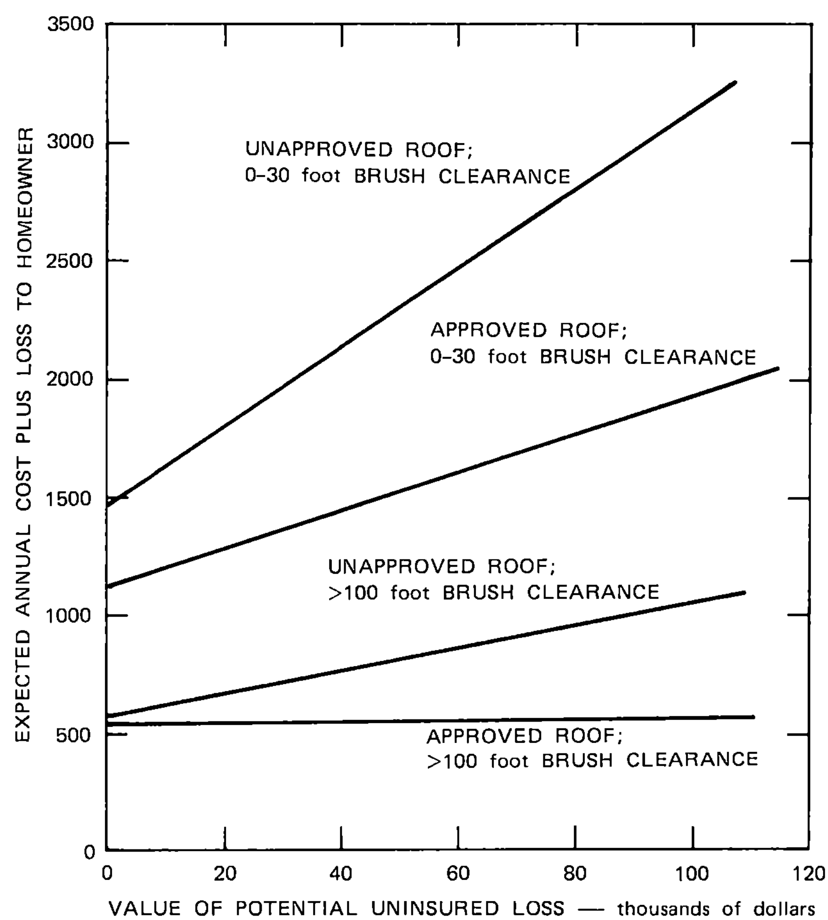
introducing a measure of risk aversion would have been the same as an increase in the value of the uninsured losses, and the figure shows that any such increase would make that alternative even more attractive than using the nominal values in the analysis.

It is also of interest to examine how potential uninsured losses affect the individual homeowner's decision in deciding what protective measures to take. Some homeowners might be indifferent to keeping their house or receiving a check for its insurable value, while others would forego a payment far in excess of the insurable value of the house rather than have it destroyed by fire. Intangible factors are important elements of the individual homeowner's decision.

In order to examine the sensitivity of the homeowner's decision to the value he assigns his potential uninsured loss, we will assume that the surcharge schedule is set so as to reflect the likelihood of destruction

observed in the Bel Air fire (see section V.C.b.). Figure 9 shows how the uninsured loss affects the homeowner's decision for homeowners in four categories of brush clearance and roof type. As before, we have assumed a $50,000 home and a 30-year cycle time and have used the probabilities of destruction given fire from the Bel Air fire.

The figure shows that under a revised surcharge schedule consistent with the Bel Air statistics, the most attractive option from the standpoint of the individual homeowner is to have both an approved roof and 100 feet of brush clearance. This conclusion is valid no matter how little or great the homeowner perceives his potential uninsured losses to be. For small values of an uninsured loss, however, there is little difference between having both brush clearance and an approved roof or



*Assumes revised surcharge schedule consistent with Bel Air destruction rates and probability of exposure of 1/30.

FIGURE 9 SENSITIVITY OF THE HOMEOWNER'S PROPERTY PROTECTION DECISION TO THE VALUE ASSIGNED TO POTENTIAL UNINSURED LOSSES*

having just brush clearance alone. The greater the uninsured losses, the more attractive it becomes to have both an approved roof and 100 feet of brush clearance.

E. Cost of Brush Clearance and Roof Conversion

Figures 10 and 11 show the dependency of our findings on the costs of brush clearance and roof conversion. The brush clearance costs would have to be more than three times our nominal value before the most attractive policy became something other than requiring both approved roofs and 100 feet of brush clearance. The annual roof conversion costs would have to be greater than $640 per year (compared with our nominal value of $390 per year) before the most attractive policy shifted to one of brush clearance alone.

Throughout our analysis we have assumed that all homeowners would clear their brush to 100 feet if that alternative were implemented. But if neighboring houses are closer than 200 feet together, it is impossible for both homeowners to clear their brush to 100 feet without duplication

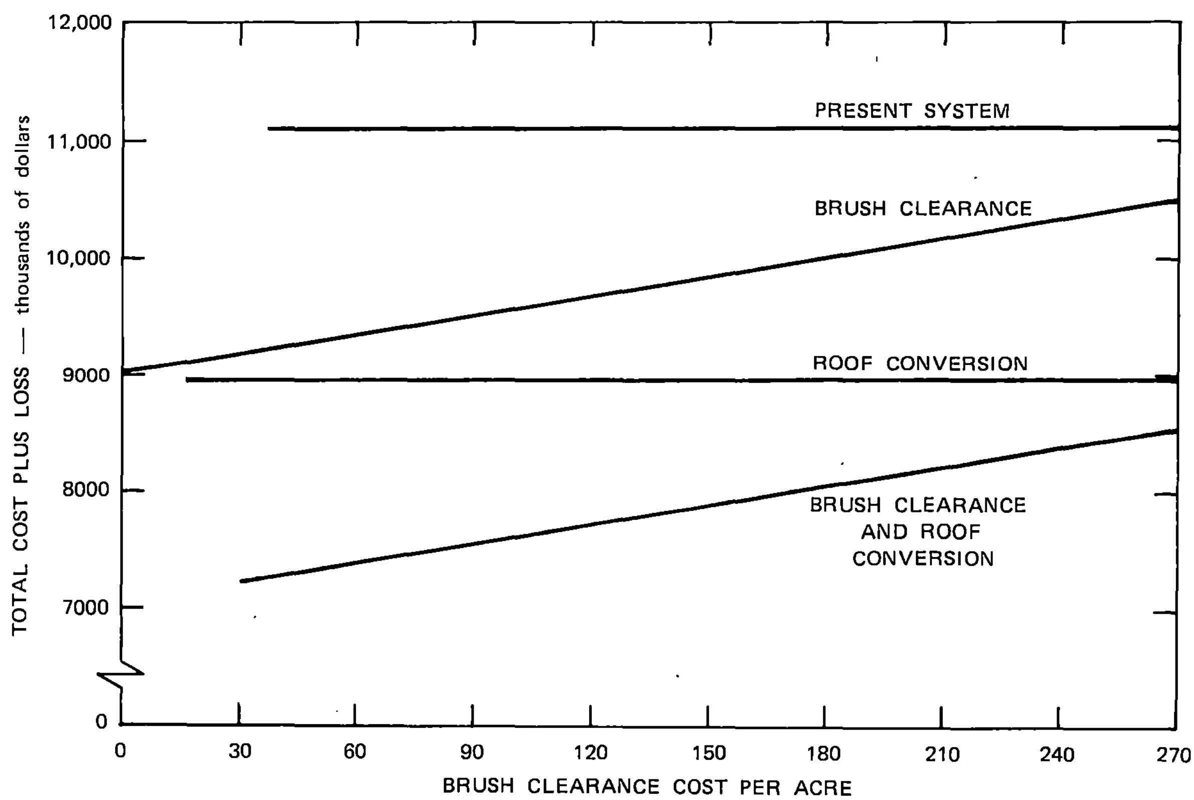


FIGURE 10 SENSITIVITY TO BRUSH CLEARANCE COST

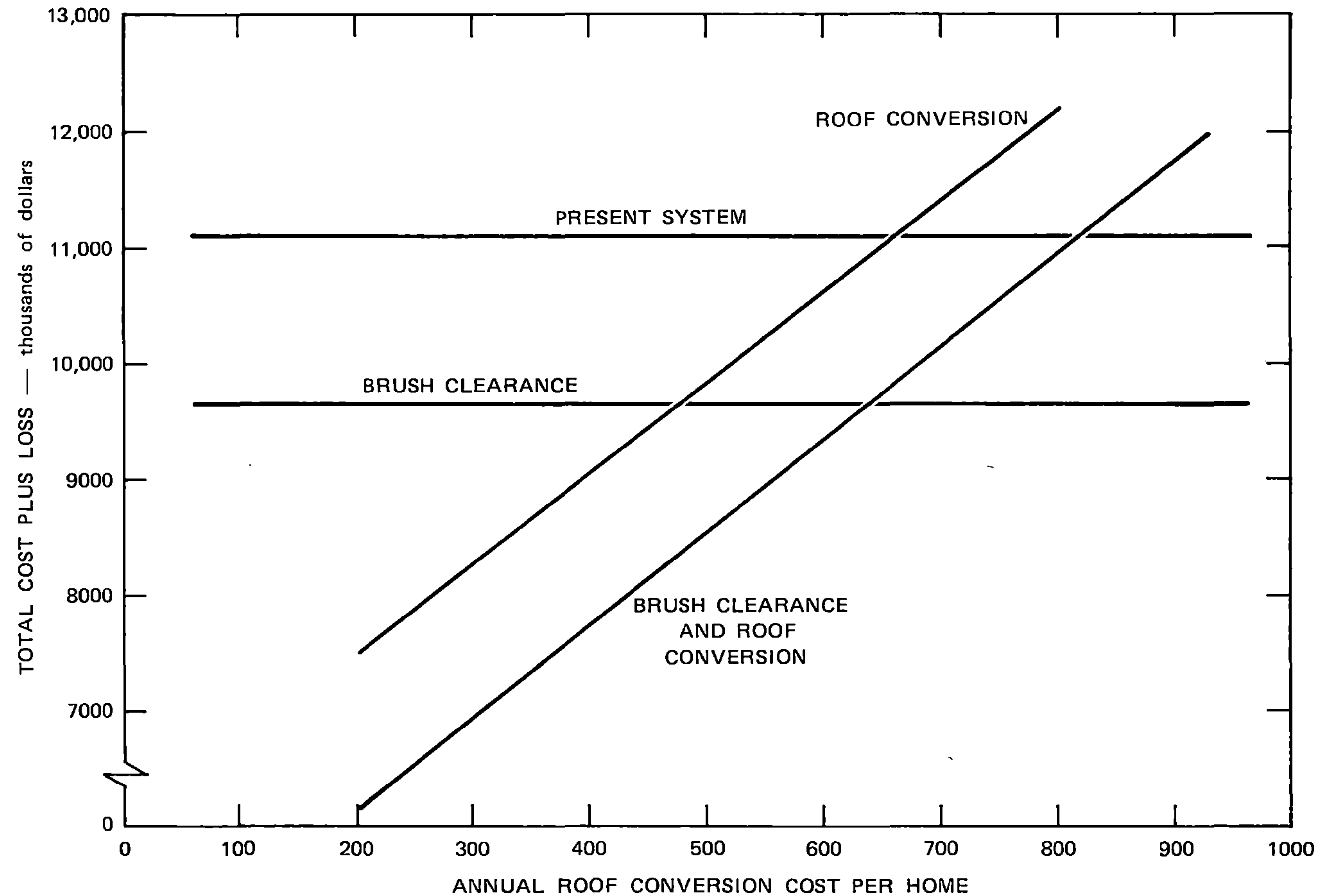


FIGURE 11 SENSITIVITY TO ROOF CONVERSION COSTS

of effort. The effect of this double accounting is to overestimate the amount of brush that must be cleared. Overestimating the amount of brush to be cleared has the same effect on total cost plus loss as overestimating the brush clearance costs per unit acre. Figure 9 shows that even if brush clearance costs were tripled, policy selection would remain the same. Thus, our results are relatively insensitive to the fact that we have overlooked the spacing between some houses in the area.

F. Other Categories of Loss

Any comprehensive assessment of fire protection policy must include the loss of human life, disruption of public services, and damages to watershed, aesthetics, wildlife, and recreation. We have used first order approximations for these various categories of loss. In the two alternatives where there were marked differences in the values assigned to these categories (i.e., reduction of conflagration incidence and extent), we found that structural losses and program costs were so great that all other categories of loss were of secondary importance. For example, even if fuel break land could be obtained for free, the nonstructural losses would only be 9 percent of the total cost plus loss under that alternative. Nonstructural losses become a significant factor in cost plus loss only when brush clearance and roof conversion have been carried out for all homes in the area. In evaluating this combined alternative we have assumed the same values for the various categories of nonstructural loss.

If complete brush clearance and roof conversion have been implemented, then the various categories of nonstructural loss would be significant in the decision to implement fuel breaks or increased prevention activity. However, in this situation the values threatened by fire would have been reduced by more than 70 percent, and it appears doubtful that additional expenditures for fire protection would be economically justified.

VII CONCLUDING REMARKS

Our analysis, supported by sensitivity studies, indicates that the most cost-effective means of protecting the Santa Monica Mountains from wildfire is for all houses to have approved roofs and 100 feet of brush clearance. Structural losses would be reduced by almost a factor of ten--from the present burn rate of 60 houses per year to 7 houses per year. These findings should be carefully examined by experts in the fire community as well as by interested members of the public. Residents, contractors, bankers, and insurance agents should be made aware that while wildfire is inevitable in the Santa Monica Mountains, certain protective measures taken in advance of fire can greatly reduce structural damage.

There are still significant uncertainties about the behavior of wildfire, particularly with respect to how fire is affected by the various preventive and suppression measures. Current research being sponsored by the U.S. Forest Service and other agencies should result in new knowledge about fire spread mechanisms, fuel characteristics, weather conditions, and geographical factors. Better understanding is also needed of the effectiveness of preventive measures, of fuel breaks, and of other suppression measures. However, the conclusions of this report are not expected to change as a result of work in these areas.

Throughout our analysis we have assumed that the destruction statistics from the Bel Air fire could be used to evaluate the effectiveness of alternative brush clearance and roof conversion programs. Improved records should be kept of future fires so as to allow for a more extensive data base in the evaluation of future fire protection policies. These records should include both the number of houses destroyed by roof type and brush clearance category and the population at risk (i.e., the number of houses in each category that were exposed to fire).

Until a better data base becomes available, it is important that our results for the various localities be examined by local fire protection experts. Whereas the Bel Air statistics may be appropriate for some localities, they may not be appropriate for other areas in the Santa Monica Mountains. Local experts might also conclude that the costs we have used for brush clearance and roof conversion are not appropriate for particular areas. Thus, our results should be viewed as a guide that experts may wish to adjust, depending on local conditions.

To illustrate the importance of structural protection, we have examined programs of brush clearance and roof conversion. However, these are not the only ways that structures can be protected from wildfire, and if future research efforts find that there are less costly or more aesthetically attractive ways of achieveing the same protection, then they should be seriously investigated. Work should be undertaken to determine the effectiveness of fire-retardant shingles. Other areas that should be investigated include the role of ornamental shrubbery in the spread and confinement of wildfire and the possibility of pruning native brush as an alternative to requiring its clearance.

The cost plus loss methodology that was employed here is readily adaptable to other wildland/urban areas. Certain refinements may be necessary, however, depending on the characteristics of the area. Watershed damage is one such area. We have used an approximate value for watershed losses, since for the purpose of evaluating fire protection strategies watershed damages were found to be of secondary importance. In other areas of Southern California, however, watershed damages play a more prominent role than in the Santa Monica Mountains, and for these areas it may be necessary to use a more precise means of assessing watershed damage.

Similarly, we have used approximate values in assessing the loss of human life, disruption of public services, and damages to aesthetics, wildlife and recreation. The approximations were sufficient for our analysis because structural losses were found to be the dominant factor in the assessment of total cost plus loss. Conditions in other areas, however, may warrant a more detailed development of these other loss categories.

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26. L. A. Sagan, "Human Costs of Nuclear Power," Science, Vol. 177, pp. 487-493 (11 August 1972).

Appendix A

BRUSH CLEARANCE AND MAINTENANCE COSTS

Appendix A

BRUSH CLEARANCE AND MAINTENANCE COSTS

In this appendix we will document the annual cost estimates used in the body of the report to approximate brush clearance and maintenance charges in the Santa Monica Mountains. Our basic approach in establishing these estimates was to develop an average figure for brush clearance in fuel break areas and then to extrapolate from this figure to get an associated cost for the private homeowner. U.S. Forest Service and Los Angeles County Fire Department personnel were consulted in formulating these costs. It should be recognized, however, that the estimates are our assessments based on our present knowledge of terrain, clearance and maintenance techniques, and the ratio of fuel break to private property costs.

To establish an overall cost structure for brush clearance and maintenance activities in a typical fuel break area, we found it useful to develop separate cost estimates for flat land and steep land. Flat terrain can be effectively defined as any land area in which mechanical clearance techniques involving bulldozers or other heavy machinery can be used efficiently. Steep terrain, on the other hand, would imply the use of more expensive hand-clearance techniques. Annual maintenance operations on both types of terrain are assumed to be carried out using hand labor and chemical herbicides. Based on these assumptions, the results in Table A-1 were obtained.

If we assume an equal distribution between steep terrain and flat terrain in the Santa Monica Mountains, an average figure of $65 per acre can be established as the annual cost of brush clearance and maintenance activities in a fuel break area. We think the corresponding cost for a private homeowner would be higher. Since the amount of land he has to clear around his home would be substantially smaller than in the fuel break case, his set-up expenses per acre would be significantly higher. Regardless of terrain, it would probably be infeasible for a landscape contractor to employ heavy machinery in clearing a small house lot of brush. Therefore, hand labor and light machinery would normally have to be used at a relatively high cost per acre. Because of these considerations, the expected charge for the

Table A-1

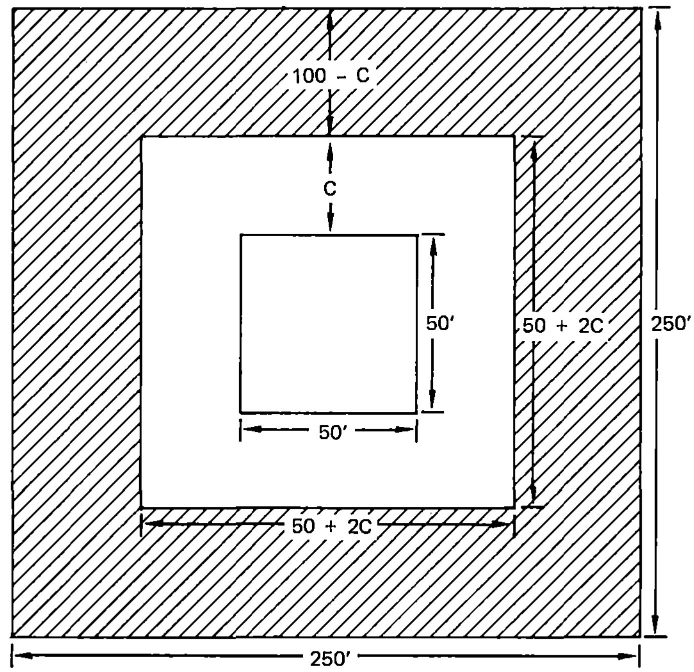
BRUSH CLEARANCE AND MAINTENANCE COSTS IN FUEL BREAK AREAS

	Steep Terrain (per acre)	Flat Terrain (per acre)
Clearance cost		
Capital cost	$700.00	$75.00
Equivalent annual cost @ 10%*	70.00	7.50
Maintenance cost		
Annual cost	30.00	20.00
Total annual cost	$100.00	$27.50

*Assuming an infinite amortization period. If a 30-year amortization period is used, the equivalent annual costs become $74 and $7.96, respectively.

individual homeowner was scaled up by two-thirds to an annual equivalent cost of $110 per acre for brush clearance and maintenance operations. (This figure corresponds very closely to "ballpark" estimates given to us by landscape contractors operating in the Santa Monica area.)

To illustrate how the $110 per acre figure can be used to calculate an actual homeowner's costs for brush clearance and maintenance activities, we can consider three hypothetical cases. In the first case, a homeowner has already cleared his brush to an average distance of 15 feet from his house; in the second and third cases he has cleared it to a distance of 45 feet and 80 feet. These distances represent the middle of the brush clearance intervals we have previously analyzed. In order to comply with the brush clearance ordinances currently in effect in the Santa Monica Mountains, each of these individuals must clear the brush to a minimum distance of 100 feet from his home. If we assume that each home is 50 feet by 50 feet in dimension and that the brush would be cleared in conformance with the "square model" used by the fire insurance companies, a schematic representation of the homeowner's problem would take the form of Figure A-1.



WHERE: C = distance already cleared of brush, and
100 - C = distance to be cleared of brush.

FIGURE A-1 SCHEMATIC REPRESENTATION OF BRUSH CLEARANCE

In the square model, the lined-in portion represents the acreage that remains to be cleared. At an average charge of $110 per acre, the additional annual cost that must be incurred in each case to clear this land and maintain it is shown in Table A-2.

Table A-2

HOMEOWNERS' BRUSH CLEARANCE AND MAINTENANCE COSTS

	Present Brush Clearance (feet)	Distance to Be Cleared (feet)	Acreage to Be Cleared (acres)	Additional Annual Cost
Case 1	15	85	1.29	$140
Case 2	45	55	0.98	110
Case 3	80	20	0.42	45

Appendix B

ROOF CONSTRUCTION AND CONVERSION COSTS

Appendix B

ROOF CONSTRUCTION AND CONVERSION COSTS

Through roofing contractors and architects, we were able to establish approximate cost estimates for constructing different types of roofs. Our inquiries yielded figures on four types of approved roofs and two types of unapproved roofs. The contractors gave their estimates in terms of the installation costs applicable to a 100 square foot area of roofing surface. Assuming that the average house roof in the Santa Monica Mountains covers about 3,000 square feet, the total installation cost and equivalent annual cost for each type of roof are shown in Table B-1.

The analysis in the body of our report has focused at several points on the homeowner's problem of converting an unapproved roof to an approved roof. To determine a representative cost figure for this operation, we assumed that a homeowner who presently had an unapproved surface, that is, shingle or untreated shake, would probably elect to convert to a treated shake roof. The relative expense and aesthetic appeal of his present surface would indicate a predilection towards the more costly treated shake roof over a metal or composition type. Normally, a treated shake roof can be directly applied over a shingle or untreated shake surface without removing the original roofing materials. Therefore, the installation costs for a treated shake roof presented in the table above apply. Consequently, the equivalent annual cost for a typical roof conversion in the Santa Monica Mountains is approximately $390.

Table B-1

ROOF CONSTRUCTION COSTS*

Roof Type	Installation Cost per 100 ft^2	Total Installation Cost (3,000 ft^2 roof)	Equivalent Annual Cost†
Approved			
Composition	$ 50	$1500	$150
Metal	110	3300	330
Clay tile	125	3750‡	375
Treated shake	130	3900	390
Unapproved			
Shingle	70	2100	210
Untreated shake	75	2250	225

*These cost figures apply to roof construction on a new home or to subsequent roof construction where the original surface does not have to be removed.

†Again, assuming an infinite amortization period. Shake or shingle roofs generally last about 25 years, and treatment is not expected to reduce this lifetime.

‡This cost estimate is exclusive of additional structural work that normally must be done on existing roofs to support a new clay tile roof.

Appendix C

ANALYSIS OF 46 LOCALITIES

Appendix C

ANALYSIS OF 46 LOCALITIES

This appendix gives an analysis of the present system of fire protection and the various alternatives of brush clearance and roof conversion for each of 46 localities within the Santa Monica Mountains. Figure C-1 shows where each of the areas is located. For purposes of reference the county areas are numbered 1 through 20, while the city areas are lettered A through Z. Most of the areas are defined so as to include either well-defined canyons or particular subdivisions within the study area.

The results summarized here are calculated exactly as in Section V.F. for the cases of Monte Nido and Mandeville Canyon. Since the areas are so small, we have not attempted to assess nonstructural losses such as watershed damages or disruption of public services.

The brush clearance and roof-type data for each area were determined from the Brush Surcharge Books supplied by the Insurance Services Office. We counted each of the 4,542 houses in the county portion of the brush hazard area, but only 10,551 of the 25,000 houses in the city portion. Our sample in the city portion averaged about 400 houses per area, and we assumed that the houses sampled were representative of the particular area. We estimated the total number of houses in each of the city areas by prorating the 14,449 houses not counted according to the density of streets and then adding these numbers to those already counted.

Real estate values were obtained from local real estate agents and officials of the Los Angeles County Tax Assessor's Office. In most cases actual records were not available to determine the average market value in the area, and the values reported here are the best estimates that the experts could provide.

This appendix is to be interpreted as a guide for making first order comparisons among the various areas. In some cases, we may have used average values representative of the entire Santa Monica region rather than the area in question. Officials who are well-acquainted with the various areas should feel free to revise the calculations to account for differences that we did not include.

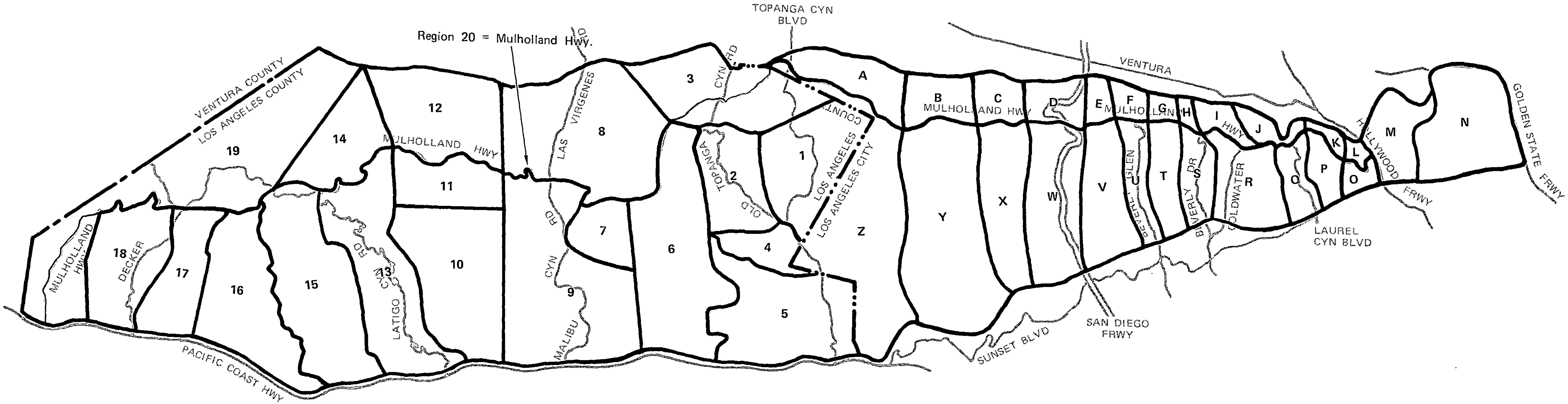


FIGURE C-1 46 LOCALITIES IN THE SANTA MONICA MOUNTAINS

AREA A S. WOODLAND HILLS - BRUSH AREA

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.006	0.000	0.006
30-60	0.032	0.032	0.065
60-100	0.052	0.026	0.078
100-	0.558	0.292	0.851
TOTAL	0.649	0.351	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample: 154
Estimated number of houses in area: 575
Average value per home: 37500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.064	0.056	0.012	0.007
Expected number of houses destroyed per year/30 year cycle time	1.233	1.082	0.235	0.134
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	46.2	40.6	8.8	5.0
Insurance systems costs	37.8	33.2	7.2	4.1
Uninsured losses	12.3	10.8	2.4	1.3
LOSS OF OTHER IMPROVEMENTS	32.1	28.2	6.1	3.5
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	6.6	0.0	6.6
Roof conversion	0.0	0.0	78.6	78.6
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	128.6	119.4	103.2	99.3

* (thousands of dollars)

AREA B S. TARZANA - BRUSH AREA

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.000	0.000	0.000
30-60	0.000	0.000	0.000
60-100	0.000	0.000	0.000
100-	1.000	0.000	1.000
TOTAL	1.000	0.000	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	4
Estimated number of houses in area:	25
Average value per home:	32500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.007	0.007	0.007	0.007
Expected number of houses destroyed per year/30 year cycle time	0.006	0.006	0.006	0.006
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	0.2	0.2	0.2	0.2
Insurance systems costs	0.2	0.2	0.2	0.2
Uninsured losses	0.1	0.1	0.1	0.1
LOSS OF OTHER IMPROVEMENTS	0.1	0.1	0.1	0.1
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	0.0	0.0	0.0
Roof conversion	0.0	0.0	0.0	0.0
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	0.5	0.5	0.5	0.5

* (thousands of dollars)

AREA C S. ENCINO - BRUSH AREA

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.007	0.000	0.007
30-60	0.016	0.023	0.039
60-100	0.020	0.029	0.049
100-	0.567	0.339	0.906
TOTAL	0.609	0.391	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	300
Estimated number of houses in area:	300
Average value per home:	37500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.068	0.062	0.011	0.007
Expected number of houses destroyed per year/30 year cycle time	0.676	0.621	0.108	0.070
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	25.4	23.3	4.1	2.6
Insurance systems costs	20.7	19.1	3.3	2.1
Uninsured losses	6.8	6.2	1.1	0.7
LOSS OF OTHER IMPROVEMENTS	17.6	16.2	2.8	1.8
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	2.2	0.0	2.2
Roof conversion	0.0	0.0	45.7	45.7
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	70.5	67.0	57.0	55.3

* (thousands of dollars)

AREA D SEPULVEDA CANYON - N. OF MULHOLLAND

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.000	0.000	0.000
30-60	0.023	0.005	0.028
60-100	0.042	0.000	0.042
100-	0.692	0.238	0.930
TOTAL	0.757	0.243	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	214
Estimated number of houses in area:	1000
Average value per home:	42500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.043	0.041	0.009	0.007
Expected number of houses destroyed per year/30 year cycle time	1.446	1.375	0.290	0.233
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	61.5	58.5	12.3	9.9
Insurance systems costs	50.3	47.8	10.1	8.1
Uninsured losses	14.5	13.8	2.9	2.3
LOSS OF OTHER IMPROVEMENTS	42.1	40.0	8.4	6.8
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	5.0	0.0	5.0
Roof conversion	0.0	0.0	94.8	94.8
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	168.3	165.0	128.5	126.9

* (thousands of dollars)

AREA E   S. SHERMAN OAKS - BRUSH AREA

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.003	0.000	0.003
30-60	0.030	0.018	0.048
60-100	0.056	0.030	0.086
100-	0.492	0.371	0.864
TOTAL	0.581	0.419	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample: 396
Estimated number of houses in area: 1575
Average value per home: 45000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.071	0.066	0.011	0.007
Expected number of houses destroyed per year/30 year cycle time	3.725	3.471	0.558	0.367
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	167.6	156.2	25.1	16.5
Insurance systems costs	137.1	127.8	20.5	13.5
Uninsured losses	37.2	34.7	5.6	3.7
LOSS OF OTHER IMPROVEMENTS	114.0	106.2	17.1	11.2
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	15.0	0.0	15.0
Roof conversion	0.0	0.0	257.5	257.5
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	456.0	439.8	325.8	317.4

* (thousands of dollars)

AREA F BEVERLY GLEN - N. OF MULHOLLAND

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.028	0.000	0.028
30-60	0.100	0.020	0.120
60-100	0.064	0.044	0.108
100-	0.375	0.371	0.745
TOTAL	0.566	0.434	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample: 251
Estimated number of houses in area: 875
Average value per home: 40000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.083	0.068	0.020	0.007
Expected number of houses destroyed per year/30 year cycle time	2.410	1.990	0.588	0.204
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	96.4	79.6	23.5	8.2
Insurance systems costs	78.9	65.1	19.3	6.7
Uninsured losses	24.1	19.9	5.9	2.0
LOSS OF OTHER IMPROVEMENTS	66.5	54.9	16.2	5.6
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	19.2	0.0	19.2
Roof conversion	0.0	0.0	148.2	148.2
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	265.9	238.7	213.1	189.9

* (thousands of dollars)

AREA G BENEDICT CANYON - N. OF MULHOLLAND

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.000	0.000	0.000
30-60	0.056	0.021	0.077
60-100	0.119	0.049	0.168
100-	0.531	0.224	0.755
TOTAL	0.706	0.294	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	143
Estimated number of houses in area:	200
Average value per home:	45000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.055	0.048	0.012	0.007
Expected number of houses destroyed per year/30 year cycle time	0.365	0.323	0.081	0.047
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	16.4	14.5	3.6	2.1
Insurance systems costs	13.5	11.9	3.0	1.7
Uninsured losses	3.7	3.2	0.8	0.5
LOSS OF OTHER IMPROVEMENTS	11.2	9.9	2.5	1.4
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	3.2	0.0	3.2
Roof conversion	0.0	0.0	22.9	22.9
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	44.7	42.7	32.8	31.8

* (thousands of dollars)

AREA H FRANKLIN CANYON - N. OF MULHOLLAND

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.000	0.000	0.000
30-60	0.089	0.044	0.133
60-100	0.089	0.067	0.156
100-	0.444	0.267	0.711
TOTAL	0.622	0.378	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	45
Estimated number of houses in area:	50
Average value per home:	42500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.071	0.060	0.015	0.007
Expected number of houses destroyed per year/30 year cycle time	0.119	0.100	0.024	0.012
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	5.0	4.3	1.0	0.5
Insurance systems costs	4.1	3.5	0.9	0.4
Uninsured losses	1.2	1.0	0.2	0.1
LOSS OF OTHER IMPROVEMENTS	3.4	2.9	0.7	0.3
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	1.1	0.0	1.1
Roof conversion	0.0	0.0	7.4	7.4
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	13.8	12.8	10.2	9.8

* (thousands of dollars)

AREA I COLDWATER CANYON - N. OF MULHOLLAND

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.029	0.000	0.029
30-60	0.087	0.025	0.112
60-100	0.050	0.075	0.124
100-	0.398	0.336	0.734
TOTAL	0.564	0.436	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	241
Estimated number of houses in area:	450
Average value per home:	47500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.083	0.068	0.020	0.007
Expected number of houses destroyed per year/30 year cycle time	1.245	1.026	0.304	0.105
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	59.1	48.8	14.4	5.0
Insurance systems costs	48.4	39.9	11.8	4.1
Uninsured losses	12.4	10.3	3.0	1.0
LOSS OF OTHER IMPROVEMENTS	40.0	33.0	9.8	3.4
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	9.9	0.0	9.9
Roof conversion	0.0	0.0	76.5	76.5
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	159.9	141.8	115.5	99.8

* (thousands of dollars)

AREA J LAUREL CANYON - N. OF MULHOLLAND

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.014	0.009	0.023
30-60	0.014	0.027	0.041
60-100	0.018	0.055	0.073
100-	0.292	0.571	0.863
TOTAL	0.338	0.662	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample: 219
Estimated number of houses in area: 975
Average value per home: 40000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.111	0.100	0.015	0.007
Expected number of houses destroyed per year/30 year cycle time	3.612	3.262	0.487	0.227
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	144.5	130.5	19.5	9.1
Insurance systems costs	118.2	106.7	15.9	7.4
Uninsured losses	36.1	32.6	4.9	2.3
LOSS OF OTHER IMPROVEMENTS	99.6	89.9	13.4	6.3
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	10.7	0.0	10.7
Roof conversion	0.0	0.0	251.8	251.8
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	398.4	370.5	305.5	287.6

* (thousands of dollars)

AREA K NICHOLS CANYON - N. OF MULHOLLAND

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.047	0.013	0.060
30-60	0.047	0.013	0.060
60-100	0.141	0.034	0.174
100-	0.584	0.121	0.705
TOTAL	0.819	0.181	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample: 149
Estimated number of houses in area: 650
Average value per home: 45000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.053	0.033	0.026	0.007
Expected number of houses destroyed per year/30 year cycle time	1.159	0.705	0.556	0.152
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	52.2	31.7	25.0	6.8
Insurance systems costs	42.7	26.0	20.5	5.6
Uninsured losses	11.6	7.1	5.6	1.5
LOSS OF OTHER IMPROVEMENTS	35.5	21.6	17.0	4.6
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	14.9	0.0	14.9
Roof conversion	0.0	0.0	45.9	45.9
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	141.9	101.3	114.0	79.4

* (thousands of dollars)

AREA L UPPER HOLLYWOOD HILLS

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.031	0.003	0.034
30-60	0.052	0.015	0.067
60-100	0.072	0.021	0.093
100-	0.577	0.229	0.807
TOTAL	0.732	0.268	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	388
Estimated number of houses in area:	750
Average value per home:	42500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.058	0.045	0.019	0.007
Expected number of houses destroyed per year/30 year cycle time	1.453	1.120	0.472	0.175
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	61.7	47.6	20.1	7.4
Insurance systems costs	50.5	38.9	16.4	6.1
Uninsured losses	14.5	11.2	4.7	1.7
LOSS OF OTHER IMPROVEMENTS	42.3	32.6	13.7	5.1
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	12.2	0.0	12.2
Roof conversion	0.0	0.0	78.4	78.4
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	169.0	142.5	133.4	110.9

* (thousands of dollars)

AREA M HOLLYWOOD RESEVOIR

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.042	0.006	0.048
30-60	0.039	0.009	0.048
60-100	0.082	0.012	0.094
100-	0.565	0.245	0.810
TOTAL	0.728	0.272	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	331
Estimated number of houses in area:	1225
Average value per home:	45000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.061	0.045	0.022	0.007
Expected number of houses destroyed per year/30 year cycle time	2.499	1.851	0.879	0.286
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	112.5	83.3	39.5	12.9
Insurance systems costs	92.0	68.2	32.4	10.5
Uninsured losses	25.0	18.5	8.8	2.9
LOSS OF OTHER IMPROVEMENTS	76.5	56.7	26.9	8.7
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	20.0	0.0	20.0
Roof conversion	0.0	0.0	139.9	139.9
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	305.9	246.6	237.5	184.9

* (thousands of dollars)

AREA N — GRIFFITH PARK

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.038	0.000	0.038
30-60	0.061	0.013	0.073
60-100	0.099	0.010	0.109
100-	0.470	0.310	0.780
TOTAL	0.668	0.332	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	313
Estimated number of houses in area:	475
Average value per home:	45000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.068	0.054	0.020	0.007
Expected number of houses destroyed per year/30 year cycle time	1.082	0.853	0.324	0.111
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	48.7	38.4	14.6	5.0
Insurance systems costs	39.9	31.4	11.9	4.1
Uninsured losses	10.8	8.5	3.2	1.1
LOSS OF OTHER IMPROVEMENTS	33.1	26.1	9.9	3.4
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	3.7	0.0	8.7
Roof conversion	0.0	0.0	61.6	61.6
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	132.5	113.1	101.2	83.8

* (thousands of dollars)

AREA O LOWER HOLLYWOOD HILLS

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.054	0.000	0.054
30-60	0.087	0.004	0.091
60-100	0.083	0.017	0.099
100-	0.682	0.074	0.756
TOTAL	0.905	0.095	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample: 242
Estimated number of houses in area: 500
Average value per home: 47500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.038	0.020	0.025	0.007
Expected number of houses destroyed per year/30 year cycle time	0.640	0.340	0.414	0.117
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	30.4	16.2	19.7	5.5
Insurance systems costs	24.9	13.2	16.1	4.5
Uninsured losses	6.4	3.4	4.1	1.2
LOSS OF OTHER IMPROVEMENTS	20.6	10.9	13.3	3.7
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	11.0	0.0	11.0
Roof conversion	0.0	0.0	18.5	18.5
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	82.2	54.7	71.7	44.5

* (thousands of dollars)

AREA P NICHOLS CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.072	0.022	0.093
30-60	0.068	0.022	0.090
60-100	0.090	0.018	0.108
100-	0.616	0.093	0.710
TOTAL	0.846	0.154	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	279
Estimated number of houses in area:	1075
Average value per home:	50000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.060	0.029	0.034	0.007
Expected number of houses destroyed per year/30 year cycle time	2.151	1.030	1.224	0.251
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	107.5	51.5	61.2	12.5
Insurance systems costs	88.0	42.1	50.1	10.3
Uninsured losses	21.5	10.3	12.2	2.5
LOSS OF OTHER IMPROVEMENTS	72.3	34.6	41.2	8.4
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	29.8	0.0	29.8
Roof conversion	0.0	0.0	64.6	64.6
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	289.3	168.3	229.4	128.2

* (thousands of dollars)

AREA Q LAUREL CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.085	0.008	0.092
30-60	0.121	0.020	0.141
60-100	0.140	0.017	0.157
100-	0.517	0.093	0.610
TOTAL	0.862	0.138	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	1323
Estimated number of houses in area:	1323
Average value per home:	40000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.059	0.026	0.037	0.007
Expected number of houses destroyed per year/30 year cycle time	2.584	1.164	1.622	0.309
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	103.3	46.6	64.9	12.3
Insurance systems costs	84.6	38.1	53.1	10.1
Uninsured losses	25.8	11.6	16.2	3.1
LOSS OF OTHER IMPROVEMENTS	71.2	32.1	44.7	8.5
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	46.9	0.0	46.9
Roof conversion	0.0	0.0	71.0	71.0
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	285.0	175.3	249.9	151.9

* (thousands of dollars)

AREA R COLDWATER CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.026	0.002	0.028
30-60	0.043	0.012	0.054
60-100	0.059	0.038	0.097
100-	0.482	0.338	0.820
TOTAL	0.610	0.390	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	423
Estimated number of houses in area:	2000
Average value per home:	65000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.073	0.062	0.017	0.007
Expected number of houses destroyed per year/30 year cycle time	4.865	4.133	1.142	0.467
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	316.2	268.7	74.2	30.3
Insurance systems costs	258.7	219.8	60.7	24.8
Uninsured losses	48.6	41.3	11.4	4.7
LOSS OF OTHER IMPROVEMENTS	207.9	176.6	48.8	19.9
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	28.6	0.0	28.6
Roof conversion	0.0	0.0	304.3	304.3
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	831.4	735.1	499.4	412.6

* (thousands of dollars)

AREA S FRANKLIN CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.022	0.013	0.035
30-60	0.061	0.026	0.088
60-100	0.092	0.066	0.158
100-	0.416	0.304	0.720
TOTAL	0.591	0.409	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	457
Estimated number of houses in area:	1600
Average value per home:	50000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.081	0.065	0.021	0.007
Expected number of houses destroyed per year/30 year cycle time	4.346	3.450	1.109	0.373
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	217.3	172.5	55.5	18.7
Insurance systems costs	177.8	141.2	45.4	15.3
Uninsured losses	43.5	34.5	11.1	3.7
LOSS OF OTHER IMPROVEMENTS	146.2	116.1	37.3	12.6
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	34.6	0.0	34.6
Roof conversion	0.0	0.0	255.3	255.3
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	584.7	498.8	404.5	340.2

* (thousands of dollars)

AREA T BENEDICT CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.035	0.015	0.050
30-60	0.098	0.027	0.125
60-100	0.088	0.042	0.131
100-	0.449	0.246	0.694
TOTAL	0.670	0.330	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	1063
Estimated number of houses in area:	1063
Average value per home:	50000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.076	0.054	0.026	0.007
Expected number of houses destroyed per year/30 year cycle time	2.692	1.898	0.915	0.248
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	134.6	94.9	45.8	12.4
Insurance systems costs	110.1	77.6	37.4	10.1
Uninsured losses	26.9	19.0	9.2	2.5
LOSS OF OTHER IMPROVEMENTS	90.6	63.8	30.8	8.3
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	28.3	0.0	28.3
Roof conversion	0.0	0.0	136.9	136.9
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	362.3	283.6	260.0	198.6

* (thousands of dollars)

AREA U BEVERLY GLEN

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.078	0.010	0.088
30-60	0.119	0.025	0.145
60-100	0.090	0.020	0.110
100-	0.540	0.117	0.658
TOTAL	0.828	0.172	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	511
Estimated number of houses in area:	2000
Average value per home:	40000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.063	0.031	0.036	0.007
Expected number of houses destroyed per year/30 year cycle time	4.200	2.085	2.372	0.467
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	168.0	83.4	94.9	18.7
Insurance systems costs	137.5	68.3	77.6	15.3
Uninsured losses	42.0	20.9	23.7	4.7
LOSS OF OTHER IMPROVEMENTS	115.8	57.5	65.4	12.9
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	66.4	0.0	66.4
Roof conversion	0.0	0.0	134.3	134.3
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	463.3	296.4	395.9	252.2

* (thousands of dollars)

AREA V BEL AIR

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.005	0.003	0.008
30-60	0.034	0.011	0.045
60-100	0.055	0.049	0.104
100-	0.434	0.410	0.844
TOTAL	0.528	0.472	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	1311
Estimated number of houses in area:	1311
Average value per home:	90000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.079	0.074	0.012	0.007
Expected number of houses destroyed per year/30 year cycle time	3.457	3.215	0.518	0.306
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	311.1	289.4	46.6	27.5
Insurance systems costs	254.5	236.8	38.1	22.5
Uninsured losses	34.6	32.2	5.2	3.1
LOSS OF OTHER IMPROVEMENTS	200.1	186.1	30.0	17.7
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	14.0	0.0	14.0
Roof conversion	0.0	0.0	241.4	241.4
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	800.3	758.4	361.3	326.2

* (thousands of dollars)

AREA W UPPER BRENTWOOD

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.009	0.000	0.009
30-60	0.061	0.012	0.074
60-100	0.092	0.018	0.110
100-	0.623	0.184	0.807
TOTAL	0.785	0.215	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample: 326
Estimated number of houses in area: 1200
Average value per home: 75000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.045	0.037	0.014	0.007
Expected number of houses destroyed per year/30 year cycle time	1.791	1.491	0.545	0.280
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	134.3	111.8	40.9	21.0
Insurance systems costs	109.9	91.5	33.4	17.2
Uninsured losses	17.9	14.9	5.5	2.8
LOSS OF OTHER IMPROVEMENTS	87.4	72.7	26.6	13.7
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	17.2	0.0	17.2
Roof conversion	0.0	0.0	100.5	100.5
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	349.5	308.2	206.9	172.4

* (thousands of dollars)

AREA X MANDEVILLE CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.005	0.003	0.008
30-60	0.036	0.024	0.060
60-100	0.061	0.041	0.102
100-	0.466	0.364	0.831
TOTAL	0.569	0.431	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	1180
Estimated number of houses in area:	1180
Average value per home:	60000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.075	0.068	0.013	0.007
Expected number of houses destroyed per year/30 year cycle time	2.961	2.668	0.493	0.275
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	177.7	160.1	29.6	16.5
Insurance systems costs	145.4	131.0	24.2	13.5
Uninsured losses	29.6	26.7	4.9	2.8
LOSS OF OTHER IMPROVEMENTS	117.5	105.9	19.6	10.9
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	14.5	0.0	14.5
Roof conversion	0.0	0.0	198.5	198.5
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	470.2	438.1	276.9	256.7

* (thousands of dollars)

AREA Y RUSTIC CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.049	0.014	0.063
30-60	0.105	0.049	0.154
60-100	0.126	0.035	0.161
100-	0.385	0.238	0.622
TOTAL	0.664	0.336	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample: 143
Estimated number of houses in area: 250
Average value per home: 55000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.083	0.054	0.031	0.007
Expected number of houses destroyed per year/30 year cycle time	0.695	0.453	0.254	0.058
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	38.2	24.9	14.0	3.2
Insurance systems costs	31.3	20.4	11.4	2.6
Uninsured losses	7.0	4.5	2.5	0.6
LOSS OF OTHER IMPROVEMENTS	25.5	16.6	9.3	2.1
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	8.2	0.0	8.2
Roof conversion	0.0	0.0	32.7	32.7
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	101.9	74.6	70.0	49.5

* (thousands of dollars)

AREA Z PALISADES HIGHLANDS

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.000	0.000	0.000
30-60	0.029	0.007	0.036
60-100	0.087	0.000	0.087
100-	0.797	0.080	0.877
TOTAL	0.913	0.087	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	138
Estimated number of houses in area:	225
Average value per home:	60000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.022	0.019	0.009	0.007
Expected number of houses destroyed per year/30 year cycle time	0.168	0.144	0.071	0.053
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	10.1	8.7	4.3	3.2
Insurance systems costs	8.2	7.1	3.5	2.6
Uninsured losses	1.7	1.4	0.7	0.5
LOSS OF OTHER IMPROVEMENTS	6.7	5.7	2.8	2.1
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	1.8	0.0	1.8
Roof conversion	0.0	0.0	7.6	7.6
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	26.7	24.7	18.9	17.7

* (thousands of dollars)

AREA 1 TOPANGA/SYLVIA PARK

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.053	0.000	0.053
30-60	0.105	0.003	0.108
60-100	0.127	0.004	0.131
100-	0.689	0.019	0.708
TOTAL	0.974	0.026	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	240
Estimated number of houses in area:	240
Average value per home:	30000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.030	0.011	0.026	0.007
Expected number of houses destroyed per year/30 year cycle time	0.728	0.262	0.634	0.173
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	21.8	7.9	19.0	5.2
Insurance systems costs	17.9	6.4	15.6	4.2
Uninsured losses	7.3	2.6	6.3	1.7
LOSS OF OTHER IMPROVEMENTS	15.7	5.6	13.6	3.7
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	18.6	0.0	18.6
Roof conversion	0.0	0.0	7.4	7.4
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	62.6	41.2	62.0	40.9

* (thousands of dollars)

AREA 2 OLD CANYON RD/TOPANGA PARK

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.097	0.000	0.097
30-60	0.164	0.000	0.164
60-100	0.188	0.000	0.188
100-	0.551	0.000	0.551
TOTAL	1.000	0.000	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	341
Estimated number of houses in area:	341
Average value per home:	25000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.039	0.007	0.039	0.007
Expected number of houses destroyed per year/30 year cycle time	0.446	0.080	0.446	0.080
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	11.2	2.0	11.2	2.0
Insurance systems costs	9.1	1.6	9.1	1.6
Uninsured losses	4.5	0.8	4.5	0.8
LOSS OF OTHER IMPROVEMENTS	8.2	1.5	8.2	1.5
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	13.7	0.0	13.7
Roof conversion	0.0	0.0	0.0	0.0
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	33.0	19.5	33.0	19.5

* (thousands of dollars)

AREA 3 CALABASAS PARK

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.018	0.000	0.018
30-60	0.041	0.015	0.055
60-100	0.044	0.015	0.059
100-	0.450	0.417	0.867
TOTAL	0.554	0.446	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample: 271
Estimated number of houses in area: 271
Average value per home: 35000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.079	0.070	0.014	0.007
Expected number of houses destroyed per year/30 year cycle time	0.710	0.632	0.131	0.063
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	24.8	22.1	4.6	2.2
Insurance systems costs	20.3	18.1	3.7	1.8
Uninsured losses	7.1	6.3	1.3	0.6
LOSS OF OTHER IMPROVEMENTS	17.4	15.5	3.2	1.6
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	3.1	0.0	3.1
Roof conversion	0.0	0.0	47.2	47.2
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	69.7	65.1	60.0	56.5

* (thousands of dollars)

AREA 4 FERNWOOD

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.036	0.000	0.036
30-60	0.119	0.002	0.122
60-100	0.179	0.007	0.186
100-	0.647	0.010	0.656
TOTAL	0.981	0.019	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample: 419
Estimated number of houses in area: 419
Average value per home: 22500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.026	0.010	0.023	0.007
Expected number of houses destroyed per year/30 year cycle time	0.358	0.135	0.319	0.098
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	8.1	3.0	7.2	2.2
Insurance systems costs	6.6	2.5	5.9	1.8
Uninsured losses	3.6	1.4	3.2	1.0
LOSS OF OTHER IMPROVEMENTS	6.1	2.3	5.4	1.7
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	11.2	0.0	11.2
Roof conversion	0.0	0.0	3.1	3.1
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	24.3	20.4	24.8	21.0

* (thousands of dollars)

AREA 5 LOWER TOPAGNA CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.061	0.003	0.064
30-60	0.058	0.003	0.061
60-100	0.094	0.015	0.109
100-	0.482	0.285	0.767
TOTAL	0.694	0.306	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	330
Estimated number of houses in area:	330
Average value per home:	37500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.069	0.050	0.026	0.007
Expected number of houses destroyed per year/30 year cycle time	0.764	0.552	0.284	0.077
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	28.6	20.7	10.7	2.9
Insurance systems costs	23.4	16.9	8.7	2.4
Uninsured losses	7.6	5.5	2.8	0.8
LOSS OF OTHER IMPROVEMENTS	19.9	14.4	7.4	2.0
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	6.8	0.0	6.8
Roof conversion	0.0	0.0	39.4	39.4
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	79.6	64.3	69.0	54.2

* (thousands of dollars)

AREA 6 LAS FLORES CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.038	0.005	0.043
30-60	0.088	0.002	0.091
60-100	0.112	0.026	0.138
100-	0.606	0.122	0.728
TOTAL	0.845	0.155	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	419
Estimated number of houses in area:	419
Average value per home:	42500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.045	0.029	0.023	0.007
Expected number of houses destroyed per year/30 year cycle time	0.627	0.403	0.316	0.098
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	26.7	17.1	13.4	4.2
Insurance systems costs	21.8	14.0	11.0	3.4
Uninsured losses	6.3	4.0	3.2	1.0
LOSS OF OTHER IMPROVEMENTS	18.3	11.7	9.2	2.8
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	9.3	0.0	9.3
Roof conversion	0.0	0.0	25.3	25.3
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	73.0	56.2	62.2	46.0

* (thousands of dollars)

AREA 7 MONTE NIDO

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.033	0.000	0.033
30-60	0.042	0.000	0.042
60-100	0.084	0.009	0.093
100-	0.763	0.070	0.833
TOTAL	0.921	0.079	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	215
Estimated number of houses in area:	215
Average value per home:	40000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.029	0.018	0.017	0.007
Expected number of houses destroyed per year/30 year cycle time	0.204	0.130	0.125	0.050
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	8.2	5.2	5.0	2.0
Insurance systems costs	6.7	4.3	4.1	1.6
Uninsured losses	2.0	1.3	1.3	0.5
LOSS OF OTHER IMPROVEMENTS	5.6	3.6	3.5	1.4
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	2.9	0.0	2.9
Roof conversion	0.0	0.0	6.6	6.6
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	22.5	17.2	20.5	15.0

* (thousands of dollars)

AREA 8 STOKES CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.000	0.000	0.000
30-60	0.000	0.000	0.000
60-100	0.000	0.000	0.000
100-	0.900	0.100	1.000
TOTAL	0.900	0.100	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	10
Estimated number of houses in area:	10
Average value per home:	30000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.021	0.021	0.007	0.007
Expected number of houses destroyed per year/30 year cycle time	0.007	0.007	0.002	0.002
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	0.2	0.2	0.1	0.1
Insurance systems costs	0.2	0.2	0.1	0.1
Uninsured losses	0.1	0.1	0.0	0.0
LOSS OF OTHER IMPROVEMENTS	0.2	0.2	0.1	0.1
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	0.0	0.0	0.0
Roof conversion	0.0	0.0	0.4	0.4
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	0.6	0.6	0.6	0.6

* (thousands of dollars)

AREA 9 MALIBU CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.019	0.000	0.019
30-60	0.039	0.004	0.043
60-100	0.062	0.004	0.066
100-	0.729	0.143	0.872
TOTAL	0.849	0.151	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	258
Estimated number of houses in area:	258
Average value per home:	57500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.036	0.028	0.014	0.007
Expected number of houses destroyed per year/30 year cycle time	0.308	0.243	0.122	0.060
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	17.7	14.0	7.0	3.5
Insurance systems costs	14.5	11.5	5.7	2.8
Uninsured losses	3.1	2.4	1.2	0.6
LOSS OF OTHER IMPROVEMENTS	11.8	9.3	4.7	2.3
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	2.7	0.0	2.7
Roof conversion	0.0	0.0	15.2	15.2
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	47.0	39.9	33.8	27.1

* (thousands of dollars)

AREA 10 CORRAL CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.033	0.000	0.033
30-60	0.098	0.000	0.098
60-100	0.098	0.011	0.109
100-	0.750	0.011	0.761
TOTAL	0.978	0.022	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	92
Estimated number of houses in area:	92
Average value per home:	42500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.023	0.010	0.020	0.007
Expected number of houses destroyed per year/30 year cycle time	0.071	0.031	0.062	0.021
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	3.0	1.3	2.6	0.9
Insurance systems costs	2.5	1.1	2.2	0.7
Uninsured losses	0.7	0.3	0.6	0.2
LOSS OF OTHER IMPROVEMENTS	2.1	0.9	1.8	0.6
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	1.9	0.0	1.9
Roof conversion	0.0	0.0	0.8	0.8
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	8.3	5.5	8.0	5.1

* (thousands of dollars)

AREA 11 MALIBU LAKE

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.011	0.006	0.017
30-60	0.102	0.003	0.105
60-100	0.133	0.003	0.136
100-	0.701	0.042	0.743
TOTAL	0.946	0.054	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample: 354
Estimated number of houses in area: 354
Average value per home: 37500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.026	0.015	0.017	0.007
Expected number of houses destroyed per year/30 year cycle time	0.301	0.172	0.202	0.083
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	11.3	6.4	7.6	3.1
Insurance systems costs	9.2	5.3	6.2	2.5
Uninsured losses	3.0	1.7	2.0	0.8
LOSS OF OTHER IMPROVEMENTS	7.9	4.5	5.3	2.2
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	7.1	0.0	7.1
Roof conversion	0.0	0.0	7.4	7.4
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	31.4	25.0	28.5	23.1

* (thousands of dollars)

AREA 12 CORNELL ROAD

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.036	0.000	0.036
30-60	0.107	0.000	0.107
60-100	0.107	0.000	0.107
100-	0.714	0.036	0.750
TOTAL	0.964	0.036	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample: 84
Estimated number of houses in area: 84
Average value per home: 30000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.026	0.012	0.021	0.007
Expected number of houses destroyed per year/30 year cycle time	0.074	0.034	0.060	0.020
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	2.2	1.0	1.8	0.6
Insurance systems costs	1.8	0.8	1.5	0.5
Uninsured losses	0.7	0.3	0.6	0.2
LOSS OF OTHER IMPROVEMENTS	1.6	0.7	1.3	0.4
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	1.8	0.0	1.8
Roof conversion	0.0	0.0	1.2	1.2
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	6.4	4.7	6.3	4.7

* (thousands of dollars)

AREA 13 LATIGO CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.030	0.000	0.030
30-60	0.066	0.005	0.071
60-100	0.066	0.010	0.076
100-	0.652	0.172	0.823
TOTAL	0.813	0.187	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample: 198
Estimated number of houses in area: 198
Average value per home: 40000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.045	0.033	0.018	0.007
Expected number of houses destroyed per year/30 year cycle time	0.296	0.220	0.120	0.046
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	11.8	8.8	4.8	1.8
Insurance systems costs	9.7	7.2	3.9	1.5
Uninsured losses	3.0	2.2	1.2	0.5
LOSS OF OTHER IMPROVEMENTS	8.2	6.1	3.3	1.3
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	3.1	0.0	3.1
Roof conversion	0.0	0.0	14.4	14.4
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	32.6	27.3	27.6	22.6

* (thousands of dollars)

AREA 14 TRIUNFO CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.065	0.000	0.065
30-60	0.161	0.000	0.161
60-100	0.097	0.000	0.097
100-	0.661	0.016	0.677
TOTAL	0.984	0.016	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample: 62
Estimated number of houses in area: 62
Average value per home: 27500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.033	0.009	0.031	0.007
Expected number of houses destroyed per year/30 year cycle time	0.068	0.019	0.063	0.014
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	1.9	0.5	1.7	0.4
Insurance systems costs	1.5	0.4	1.4	0.3
Uninsured losses	0.7	0.2	0.6	0.1
LOSS OF OTHER IMPROVEMENTS	1.4	0.4	1.3	0.3
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	1.9	0.0	1.9
Roof conversion	0.0	0.0	0.4	0.4
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	5.4	3.5	5.5	3.5

* (thousands of dollars)

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.021	0.000	0.021
30-60	0.063	0.000	0.063
60-100	0.052	0.010	0.063
100-	0.698	0.156	0.854
TOTAL	0.833	0.167	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	96
Estimated number of houses in area:	96
Average value per home:	50000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.039	0.030	0.015	0.007
Expected number of houses destroyed per year/30 year cycle time	0.124	0.098	0.049	0.022
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	6.2	4.9	2.5	1.1
Insurance systems costs	5.1	4.0	2.0	0.9
Uninsured losses	1.2	1.0	0.5	0.2
LOSS OF OTHER IMPROVEMENTS	4.2	3.3	1.7	0.8
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	1.2	0.0	1.2
Roof conversion	0.0	0.0	6.2	6.2
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	16.7	14.3	12.9	10.5

* (thousands of dollars)

AREA 16 TRANCAS CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.015	0.000	0.015
30-60	0.026	0.003	0.029
60-100	0.032	0.006	0.038
100-	0.507	0.411	0.918
TOTAL	0.581	0.419	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	341
Estimated number of houses in area:	341
Average value per home:	40000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.072	0.066	0.012	0.007
Expected number of houses destroyed per year/30 year cycle time	0.313	0.752	0.138	0.080
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	32.5	30.1	5.5	3.2
Insurance systems costs	26.6	24.6	4.5	2.6
Uninsured losses	8.1	7.5	1.4	0.8
LOSS OF OTHER IMPROVEMENTS	22.4	20.7	3.3	2.2
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	2.4	0.0	2.4
Roof conversion	0.0	0.0	55.8	55.8
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	89.6	85.3	71.0	66.9

* (thousands of dollars)

AREA 17 ENCINAL CANYON

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.000	0.000	0.000
30-60	0.250	0.000	0.250
60-100	0.042	0.000	0.042
100-	0.667	0.042	0.708
TOTAL	0.958	0.042	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	24
Estimated number of houses in area:	24
Average value per home:	37500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.025	0.013	0.019	0.007
Expected number of houses destroyed per year/30 year cycle time	0.020	0.010	0.015	0.006
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	0.7	0.4	0.6	0.2
Insurance systems costs	0.6	0.3	0.5	0.2
Uninsured losses	0.2	0.1	0.2	0.1
LOSS OF OTHER IMPROVEMENTS	0.5	0.3	0.4	0.1
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	0.7	0.0	0.7
Roof conversion	0.0	0.0	0.4	0.4
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	2.1	1.8	2.0	1.7

* (thousands of dollars)

AREA 18 DECKER ROAD

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.121	0.000	0.121
30-60	0.112	0.000	0.112
60-100	0.262	0.000	0.262
100-	0.505	0.000	0.505
TOTAL	1.000	0.000	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample: 107
Estimated number of houses in area: 107
Average value per home: 35000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.043	0.007	0.043	0.007
Expected number of houses destroyed per year/30 year cycle time	0.154	0.025	0.154	0.025
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	5.4	0.9	5.4	0.9
Insurance systems costs	4.4	0.7	4.4	0.7
Uninsured losses	1.5	0.2	1.5	0.2
LOSS OF OTHER IMPROVEMENTS	3.8	0.6	3.8	0.6
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	4.4	0.0	4.4
Roof conversion	0.0	0.0	0.0	0.0
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	15.2	6.9	15.2	6.9

* (thousands of dollars)

AREA 19 VENTURA COUNTY BORDER

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.000	0.000	0.000
30-60	0.000	0.000	0.000
60-100	0.500	0.000	0.500
100-	0.500	0.000	0.500
TOTAL	1.000	0.000	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	2
Estimated number of houses in area:	2
Average value per home:	32500

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.012	0.007	0.012	0.007
Expected number of houses destroyed per year/30 year cycle time	0.001	0.000	0.001	0.000
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	0.0	0.0	0.0	0.0
Insurance systems costs	0.0	0.0	0.0	0.0
Uninsured losses	0.0	0.0	0.0	0.0
LOSS OF OTHER IMPROVEMENTS	0.0	0.0	0.0	0.0
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	0.0	0.0	0.0
Roof conversion	0.0	0.0	0.0	0.0
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	0.1	0.1	0.1	0.1

* (thousands of dollars)

Note: Due to the small number of houses in the area, many of the cost and loss elements are neglible, and hence reported as zero. Some of the houses in the Ventura County Border area are in the Mulholland Highway sample.

BRUSH CLEARANCE (FT)	PROPORTION APPROVED	PROPORTION UNAPPROVED	TOTAL
0-30	0.039	0.000	0.039
30-60	0.123	0.000	0.123
60-100	0.179	0.006	0.184
100-	0.609	0.045	0.654
TOTAL	0.950	0.050	1.000

PRESENT DISTRIBUTION OF HOUSES

Number of houses in sample:	179
Estimated number of houses in area:	179
Average value per home:	35000

	PRESENT MIX	CLEARED BRUSH	CONVERTED ROOFS	CLEARED BRUSH and CONVERTED ROOFS
Destruction rate/fire	0.031	0.014	0.024	0.007
Expected number of houses destroyed per year/30 year cycle time	0.183	0.084	0.141	0.042
LOSSES FROM DESTROYED DWELLINGS *				
Dwellings	6.4	2.9	4.9	1.5
Insurance systems costs	5.2	2.4	4.0	1.2
Uninsured losses	1.8	0.8	1.4	0.4
LOSS OF OTHER IMPROVEMENTS	4.5	2.1	3.5	1.0
PROGRAM IMPLEMENTATION COSTS				
Brush clearance	0.0	4.9	0.0	4.9
Roof conversion	0.0	0.0	3.5	3.5
TOTAL STRUCTURAL LOSSES AND IMPLEMENTATION COSTS	18.0	13.1	17.4	12.5

* (thousands of dollars)

Appendix D

INSURANCE SURCHARGE REVENUES

Appendix D

INSURANCE SURCHARGE REVENUES

Officials in the insurance industry have speculated that the brush surcharge is inadequate to cover expected claims from wildfire in the Santa Monica Mountains. This appendix will compare estimated surcharge revenues with expected annual claims. The calculations, which are based on several simplifying assumptions, should be viewed as first order approximations of the actual costs and revenues.

Table D-1 shows the number of homes in the city and county portions of the Santa Monica Mountains by protection class. The distributions of houses for these areas by roof type and brush clearance are given in Table D-2 and Table D-3. Since roof type and brush clearance distributions were not recorded by protection class in the county area, we will assume that the same distribution applies to each protection class.

Table D-1

NUMBER OF HOUSES BY PROTECTION CLASS*

Protection Class	City	County
1-4	22,857	0
5-6	0	2,297
7-8	0	1,716
9-10	0	519

*From Brush Surcharge Books available from Insurance Services Office.

Table D-2

DISTRIBUTION OF HOUSES BY ROOF TYPE AND BRUSH CLEARANCE IN THE CITY PORTION OF THE SANTA MONICA MOUNTAINS*

Brush Clearance (feet)	Approved Roof (percent)	Unapproved Roof (percent)
0-30	3.1	0.6
30-60	6.5	1.9
60-100	8.0	3.3
more than 100	49.8	26.7

*From Brush Surcharge Books available from Insurance Services Office.

Table D-3

DISTRIBUTION OF HOUSES BY ROOF TYPE AND BRUSH CLEARANCE IN THE COUNTY PORTION OF THE SANTA MONICA MOUNTAINS*

Brush Clearance (feet)	Approved Roof (percent)	Unapproved Roof (percent)
0-30	4.1	0.1
30-60	8.9	0.3
60-100	11.4	0.8
more than 100	62.4	12.0

*From Brush Surcharge Books available from Insurance Services Office.

The average surcharge per home in a particular protection class is found by multiplying the average surcharge rate by the average value per home. The average surcharge rate is determined by multiplying the fraction of houses in each roof type and brush clearance category by the appropriate charge for that category and then summing over all categories of roof type and brush clearance. Thus, the average surcharge rate for protection class 4B is

$$\begin{aligned} E(\text{surcharge rate} \mid \text{protection class 4B}) &= (.40)(.031) + (.36)(.065) \\ &+ (.28)(.080) + (.16)(.498) \\ &+ (.50)(.006) + (.45)(.019) \\ &+ (.35)(.033) + (.20)(.267) \\ &= \$0.214/\text{hundred dollars coverage.} \end{aligned}$$

The expected surcharge for a $50,000 house in protection class 4B is therefore:

$$\begin{aligned} E(\text{surcharge} \mid \$50{,}000 \text{ home, protection class 4B}) &= 500 \times .214 \\ &= \$107.00 \end{aligned}$$

The expected surcharges for the other protection classes are calculated in exactly the same manner. Table D-4 summarizes the expected surcharges and revenues derived from each protection class. Here we have used the surcharge rates for class B (slow) fire department response time. The effect of this assumption is to overestimate the revenues because, in fact, many of the areas have class A fire department response time, which gives them a lower surcharge rate.

Table D-4

SURCHARGE REVENUES FOR THE SANTA MONICA MOUNTAINS

Protection Class*	Expected Surcharge Revenue per House	Number of Houses	Surcharge Revenue
1-4	$107	22,857	$2,445,700
5-6	146	2,297	335,400
7-8	197	1,716	338,000
9-10	600	519	311,400
			$3,430,500

*Assumes class B (slow) fire department response time.

Table D-4 shows that the total surcharge revenues are about \$3.4 million per year. This is a upper bound because we have assumed that all houses have class B fire department response time and at most 100 feet of brush clearance. If we repeat the above calculations for the class A surcharge rates and assume that 75 percent of the houses have class A coverage and the remainder class B, we find that the surcharge revenues are approximately \$2.5 million per year.

As described in Section III B, we estimated the annual burn rate to be approximately 60 houses per year. If the insured damage per burned house is \$50,000, the expected claim is \$3.0 million per year, roughly equal to expected revenues.

But the \$3.0 million applies only to claims; it does not include the costs associated with providing insurance, which we have called the insurance systems cost. As discussed in Section III C, the insurance systems costs are about 45/55 of the actual claims, or an additional \$2.5 million per year. Thus, the costs to the insurance industry of insuring the Santa Monica Mountains from wildfire are more realistically about \$5.5 million per year. This is considerably more than the \$3.4 million in surcharge revenues estimated above, even though we used assumptions that tended to overestimate the actual revenues. Thus, the insurance industry may expect to lose an average of \$2-3 million per year under the present surcharge schedule.

Another way to evaluate the surcharge schedule is to calculate what the expected burn rate would have to be in order for the insurance industry to break even. Assuming that surcharge revenues are \$2.5 million per year and that the insurance industry just breaks even under the criterion discussed in Section III C, we find that on the average \$1.4 million would go to claims and the other \$1.1 million would pay for insurance systems costs. At \$50,000 per destroyed home, the \$1.4 million would cover 28 homes. Thus, we find the burn rate would have to be 28 houses per year, or about one-half of the present rate, for the insurance industry to break even under the present surcharge rate structure. For the insurance industry to break even when insurance systems costs are 45/55 of actual claims and an average burn rate is 60 houses per year, the surcharge revenue would have to be increased by slightly more than a factor of two.

Appendix E

THE ROLLING HILLS FIRE OF JUNE 22, 1973

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After our Santa Monica report went to press, we had an opportunity to investigate the Rolling Hills fire of June 22, 1973. The fire burned 897 acres and destroyed 12 homes south of Los Angeles, mostly in the city of Rolling Hills. The burn area was similar in many respects to areas of the Santa Monica Mountains, having a rugged terrain and an extensive wildland/urban interface. Because of these similarities, it seemed that this would be a good fire to use for checking some of our results. We were particularly interested in the roles of roof type and brush clearance, since these factors were found to be important in the analysis of fire protection for the Santa Monica Mountains.

The survey team consisted of personnel from Stanford Research Institute, the Los Angeles County Fire Department, and the Insurance Services Office. Representing SRI were Dr. Fred L. Offensend and Mr. Charles N. Smart of the Decision Analysis Group; officials from the Fire Department included Battalion Chief Raymond E. Brunstrom, and Captains John Conley, James Hensley, and Donald Moore; Mr. Creighton J. Tevlin represented the Insurances Services Office. The survey took place July 23-24, 1973, approximately one month after the fire.

There were 113 houses within the burn perimeter; we surveyed each with respect to roof type and brush clearance. The results of the survey are shown in Table E-1 for all houses in the burn area, including those destroyed. Here we have used the notation "approved roof" to designate those roof types (metal, tile, slate, and composition) that are recognized by the insurance industry as being fire resistant. Shake and shingle roofs are considered to be unapproved. We have also shown the distribution of houses as a fraction of the total surveyed.

A similar table including only the houses destroyed is presented as Table E-2. Eleven of the 12 houses destroyed had shake or shingle roofs. Nine had brush clearances of more than 100 feet, and only one had a brush clearance of less than 60 feet. Of the two factors, it is evident that roof type was the dominant factor in the destruction of the Rolling Hills fire.

Table E-1

DISTRIBUTION OF HOUSES BY BRUSH CLEARANCE AND ROOF TYPE
WITHIN BURN PERIMETER OF ROLLING HILLS FIRE, JUNE 22, 1973
(a) Number of Houses

Brush Clearance (feet)	Approved Roofs	Unapproved Roofs	Total
0-30	0	1	1
30-60	4	9	13
60-100	3	6	9
Over 100	29	61	90
Total	36	77	113

(b) Fraction of Houses

Brush Clearance (feet)	Approved Roofs	Unapproved Roofs	Total
0-30	0.000	0.009	0.009
30-60	0.035	0.080	0.115
60-100	0.027	0.053	0.080
Over 100	0.256	0.540	0.796
Total	0.318	0.682	1.000

Table E-2

HOUSES DESTROYED IN ROLLING HILLS FIRE
(Number of Houses)

Brush Clearance (feet)	Approved Roofs	Unapproved Roofs	Total
0-30	0	1	1
30-60	0	0	0
60-100	0	2	2
Over 100	1	8	9
Total	1	11	12

Of the 12 houses destroyed, we were able to determine that at least 9 had roof ignitions. In three cases we determined this from neighbors who had observed the fire. Six of the other houses had so much green vegetation remaining around them that they must have been ignited by embers landing on the roof. Brilliant flowers were still blooming less than four feet from the foundation of one house.

Shake and shingle roofs were an important factor in the overall damage. The only remaining house on Running Brand Road had an asbestos roof, while the three houses destroyed there all had shake or shingle roofs. What makes the surviving house even more dramatic is that it had a bird house sitting on the roof, which was destroyed by fire. The bird house had a shake roof. Also, there was a tree house in a eucalyptus tree only 15 to 20 feet from the dwelling itself; the tree house was destroyed, but the only damage to the main dwelling was a broken window.

Comparison with Bel Air Fire

Although the two areas were different, it is of interest to compare the Rolling Hills fire with the Bel Air fire of 1961. Tables E-3 and E-4 give the destruction rates for both fires by roof type and brush clearance. Because of the small number of houses in the Rolling Hills fire, it is difficult to make meaningful comparisons for each of the categories. For most categories, however, we do note the same general trends for both fires: the likelihood of destruction increases with wooden roofs and narrow brush clearances. The one category (unapproved roofs and more than 100 feet of brush clearance) that had the largest number of houses (61) in the Rolling Hills fire had about the same destruction rate as the equivalent category in the Bel Air fire (13.1% versus 14.8%).

Table E-3

DESTRUCTION RATES FOR ROLLING HILLS FIRE

Brush Clearance (feet)	Approved Roofs	Unapproved Roofs
0-30	*	1/1 = 1.000
30-60	0/4 = 0.000	0/9 = 0.000
60-100	0/3 = 0.000	2/6 = 0.333
Over 100	1/29 = 0.034	8/61 = 0.131

*No houses in this category.

Table E-4

DESTRUCTION RATES FOR BEL AIR FIRE

Brush Clearance (feet)	Approved Roofs	Unapproved Roofs
0-30	67/275 = 0.243	158/319 = 0.495
30-60	13/239 = 0.054	104/363 = 0.286
60-100	2/118 = 0.016	28/195 = 0.144
Over 100	1/151 = 0.007	31/210 = 0.148

The overall destruction rate of the Rolling Hills fire was very close to what we would have predicted if we had used the Bel Air statistics as our basis for the prediction. Using the methodology developed in our Santa Monica report, the predicted overall destruction rate is found by multiplying the destruction rate for each brush clearance/roof type category by the fraction of houses in that category, and then summing over all categories. Thus, using the data in Tables E-1 and E-4, the expected destruction rate predicted before the fire for the Rolling Hills area would have been

$$\begin{aligned} E\ (\text{destruction rate} \mid \text{fire}) = {} & (.243)(.000) + (.054)(.035) \\ & + (.016)(.027) + (.007)(.256) \\ & + (.495)(.009) + (.286)(.080) \\ & + (.144)(.053) + (.148)(.540) \\ = {} & 0.118 \end{aligned}$$

Thus, given a wildfire, we would have predicted a destruction rate of 11.8 percent. Therefore, for the 113 houses in the exposed area we would have predicted an expected destruction of 13.3 houses. This compares with the actual destruction of 12 houses.

The similarity of the two destruction patterns gives support to the idea that the Bel Air data can be applied to other southern California urban/wildland areas.

The Effect of Having All Fire Resistant Roofs

Assuming that the Bel Air statistics are appropriate for the Rolling Hills area, we can calculate what the destruction would have been if all the houses had had fire resistant roofs, leaving brush clearance at its present level. In this case, the distribution of houses would be as shown in Table E-5. As before, the overall destruction rate would be found by multiplying the individual destruction rates by the fraction of houses in each roof type/brush clearance category, and then summing over all the categories. Such a calculation gives a destruction of 1.7 houses. Thus, the expected destruction could have been reduced by approximately 10 houses, or 85 percent, if all the houses had had fire resistant roofs.

Table E-5

DISTRIBUTION OF HOUSES IN BURN PERIMETER OF ROLLING HILLS FIRE IF ALL HOUSES HAD FIRE RESISTANT ROOFS
(Number of Houses)

Brush Clearance (feet)	Approved Roofs	Unapproved Roofs
0-30	1	0
30-60	13	0
60-90	9	0
Over 100	90	0
Total	113	0

To determine whether it would be economically justifiable to have fire resistant roofs in the Rolling Hills area, we will use the methodology developed in our Santa Monica report. We will compare the annualized cost of roof conversion with the average annual reductions in damage. Because of the relatively small area within the burn perimeter we will consider only structural damage, and will not include changes in the damage to other categories, such as watershed, aesthetics, wildlife, and recreation.

Using the Bel Air statistics, we calculated that if a fire went through the Rolling Hills area it would destroy 13.3 houses on the average. If we use the same assumption as in our Santa Monica analysis--that the area is

exposed to wildfire once every 30 years--the expected annual burn rate is found to be

$$\begin{aligned} E\ (\text{burn rate}) &= E\ (\text{destruction} \mid \text{fire}) \times P\ (\text{fire}) \\ &= 13.3 \times 1/30 \\ &= 0.44 \text{ houses per year} \end{aligned}$$

Table E-6 gives a summary of the structural losses that are associated with an average burn rate of 0.44 house per year. In computing the figures shown for "dwellings," we have assumed that the average structure and contents are insured for $110,000 per house. The insurance systems costs are the costs of providing insurance coverage over and above actual claims and they average about 82 percent of the insured claims. The uninsured losses include those damages (both real and intangible) that are not covered by fire insurance, and we assume they average $20,000 per burned house. Based on past fire experience, we assume that damages to improvements other than dwellings average one-third of the dwelling losses (including insurance systems costs and nonstructural losses). The table shows that under the present mix of houses the average loss from wildfire is $129,100 per year.

Also given in Table E-6 are the costs and losses that would be incurred if all the houses in the area had approved roofs. For this calculation we used an expected annual burn rate of 0.06 house per year--which was found by multiplying the destruction rate given a fire and all approved roofs (1.7 houses) by the probability of a wildfire in any one year (1/30). In calculating the cost of converting the roofs to fire-resistant types, we assumed that the present shake roofs would be replaced with the pressure treated shakes that are approved by the insurance industry as being fire retardant. We assumed that the average house in the area has a 3,500-square-foot roof. Using the roofing data given in our Santa Monica report, the equivalent annual cost, at 10 percent interest, of having such a roof installed is $455 per year. Other fire resistant roofing materials would be somewhat less.

Table E-6 shows that, even when we consider roof conversion costs, the cost plus loss due to wildfire in the Rolling Hills area would be reduced by more than a factor of two if all houses had fire resistant roofs. The annualized cost of $35,000 per year of converting the roofs would be more than offset by the expected reduction in structural losses of $111,500 per year. We should note that the specific results given here pertain only to the survey area--those areas of Rolling Hills and Portuguese Bend burned in the fire of June 22, 1973. If we extended our analysis to include the entire Rolling Hills area, the magnitude of the numbers would increase but the trends would remain the same because of the general similarity of the overall area.

Table E-6

NET SAVINGS FROM USE OF FIRE RESISTANT ROOFS
(Expected Annual Cost Plus Loss Due to
Wildfire in Rolling Hills Survey Area)

	With Present Mix of Houses	If All Houses Had Fire Resistant Roofs
Average number of houses destroyed per year, 30-year cycle time	0.44	0.06
Structural losses		
Losses from destroyed dwellings		
Dwellings	$ 48,400	$ 6,600
Insurance systems costs	39,600	5,400
Uninsured losses	8,800	1,200
Loss of other improvements	32,300	4,400
Annualized cost of roof conversion	0	35,000
Total structural losses and roof conversion costs	$129,100	$52,600

Both the physical evidence and our analytical results show that roof type was a significant factor in the Rolling Hills fire. The survey team also found some other steps that could be taken to further protect the area from fire. Most notably we found several houses with poor weed abatement. Other houses had combustible materials scattered dangerously close to the sides of the structure. Many streets and houses had difficult access, particularly from the standpoint of firemen who are unfamiliar with the area. These are all significant factors, but the most important is roof conversion. Our analysis shows that conversion of all roofs to approved types would reduce structural losses by 85 percent.